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Schneider et al.

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(54) **INERT AND PRESSURE-ACTUATED SUBMUNITIONS DISPENSING PROJECTILE**

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(73) Assignee: **The United States of America as Represented by the Secretary of the Navy**

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 2 days.

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(22) Filed: **Mar. 7, 2013**

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F42B 12/60	(2006.01)
F42B 12/64	(2006.01)

(52) **U.S. Cl.**

CPC ***F42B 12/60*** (2013.01)

USPC **102/489**; 102/520; 102/449; 102/457

(58) **Field of Classification Search**

CPC F42B 12/64; F42B 14/065; F42B 7/10

USPC 102/393, 438, 448, 449, 456, 457, 489, 102/506, 520, 521, 522, 703

See application file for complete search history.

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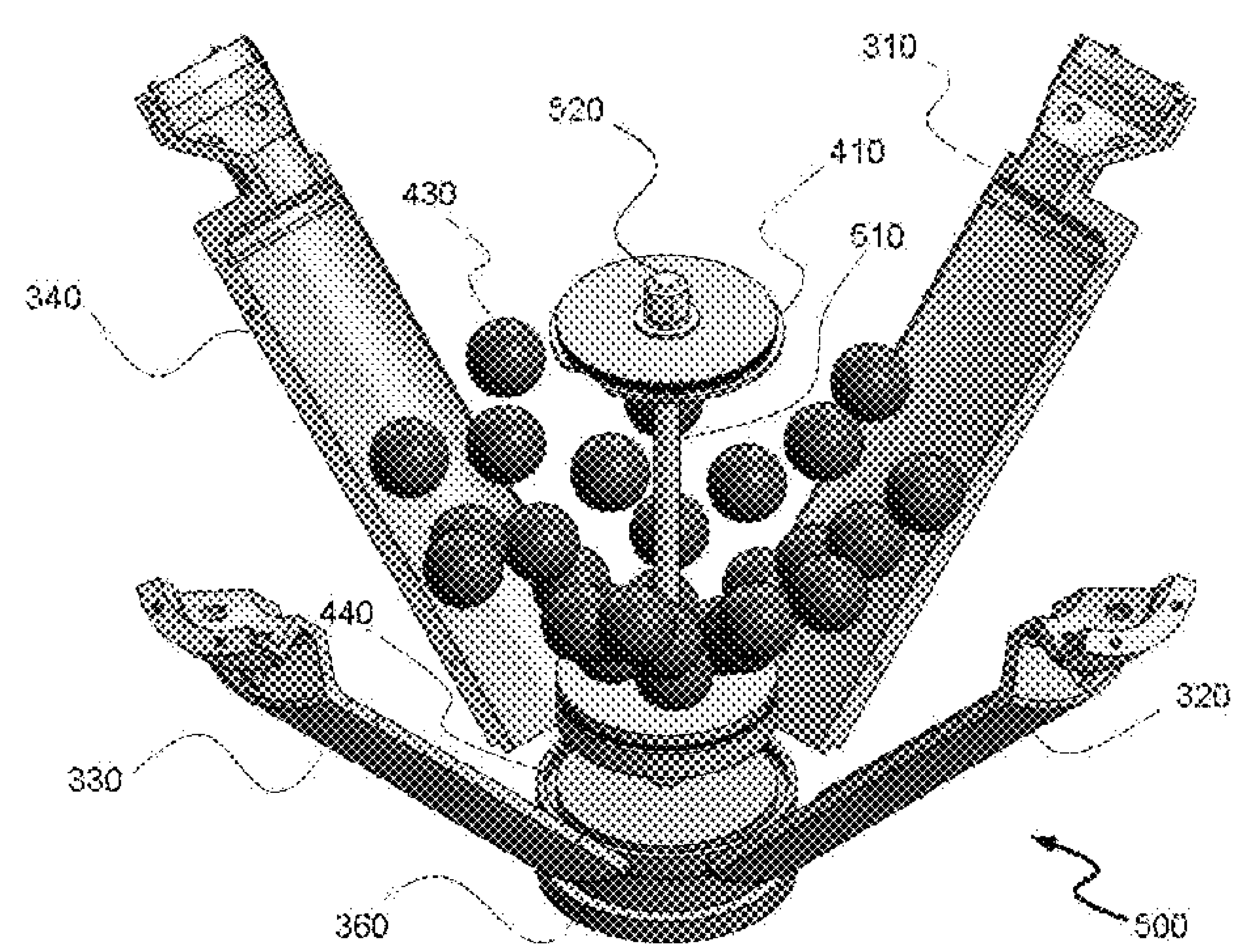
(57) **ABSTRACT**

An inert axisymmetric projectile is provided for launching from a shipboard gun and dispersing submunitions at a target. The projectile includes a base plug, a sabot housing, a submunitions package, and a retainer ring. The sabot housing includes a plurality of sabot petals angularly arranged and attached to the plug. The housing includes a payload portion and a nose portion, with a passage corridor between these portions. The submunitions package is contained within the payload portion and constrained radially by the housing. The retainer ring constrains the petals for joining together. Upon launch aerodynamic pressure fractures the ring and causes the petals to unfurl, thereby releasing the submunitions package for dispersal.

9 Claims, 21 Drawing Sheets



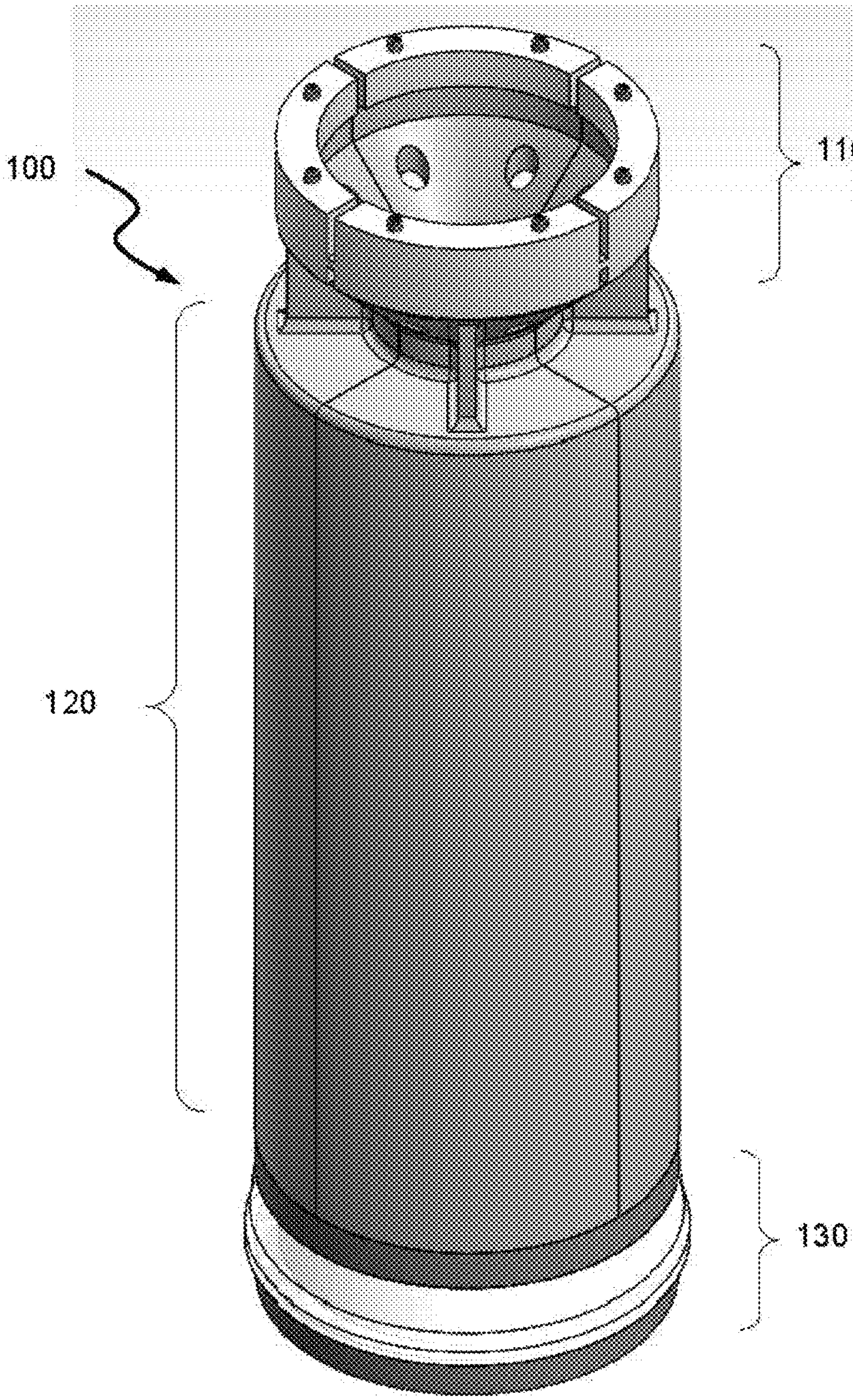


FIG. 1

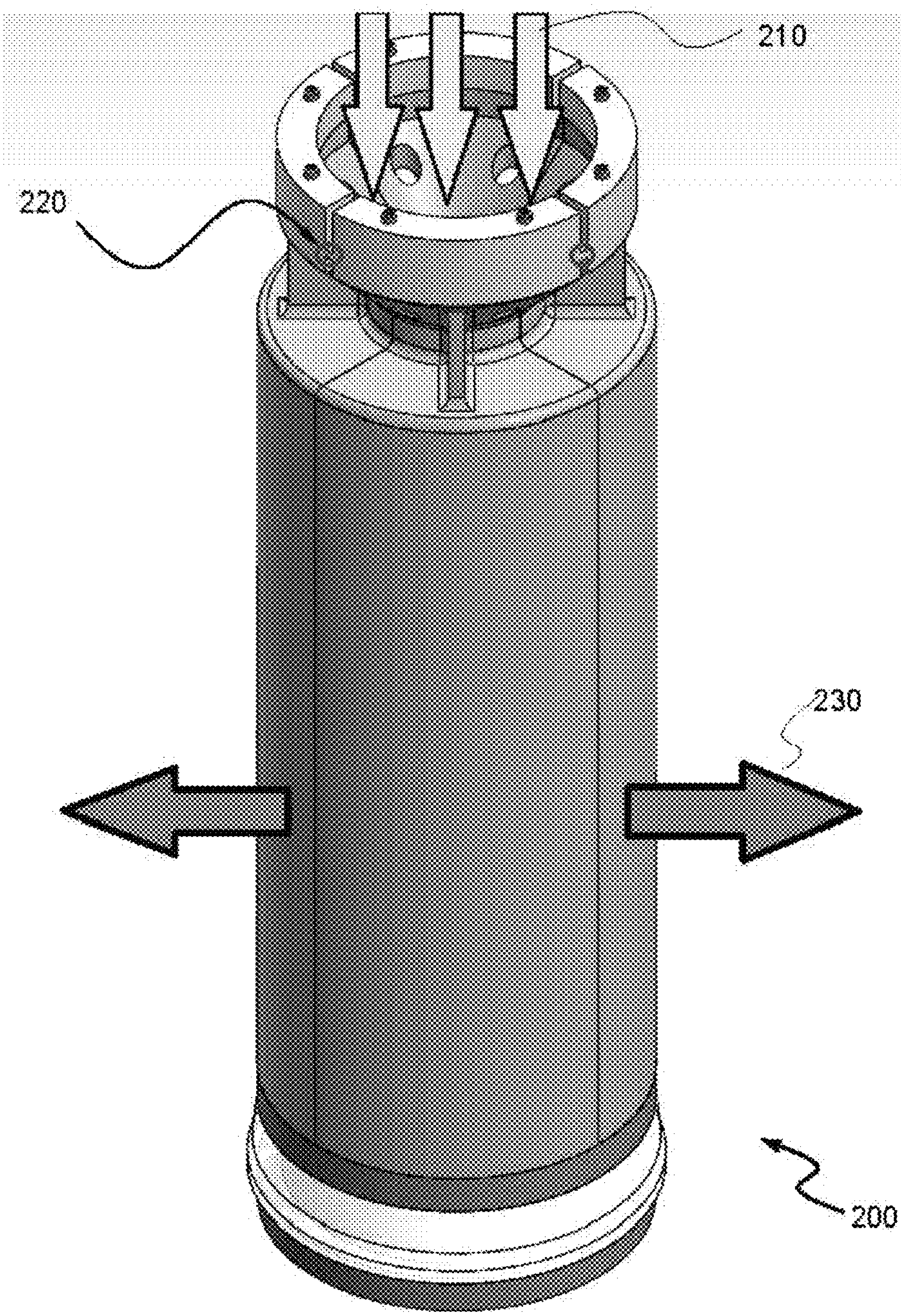


FIG. 2

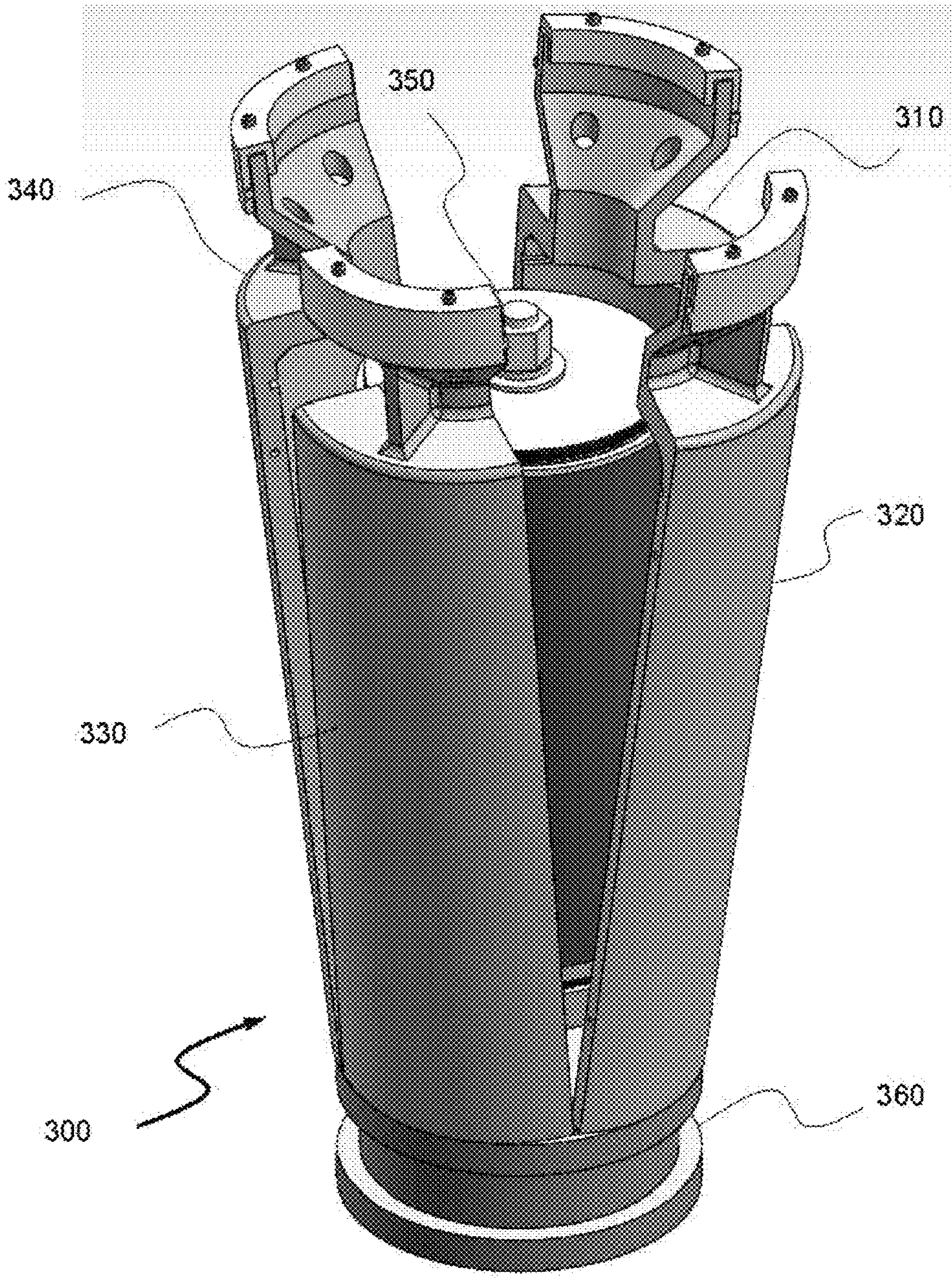


FIG. 3

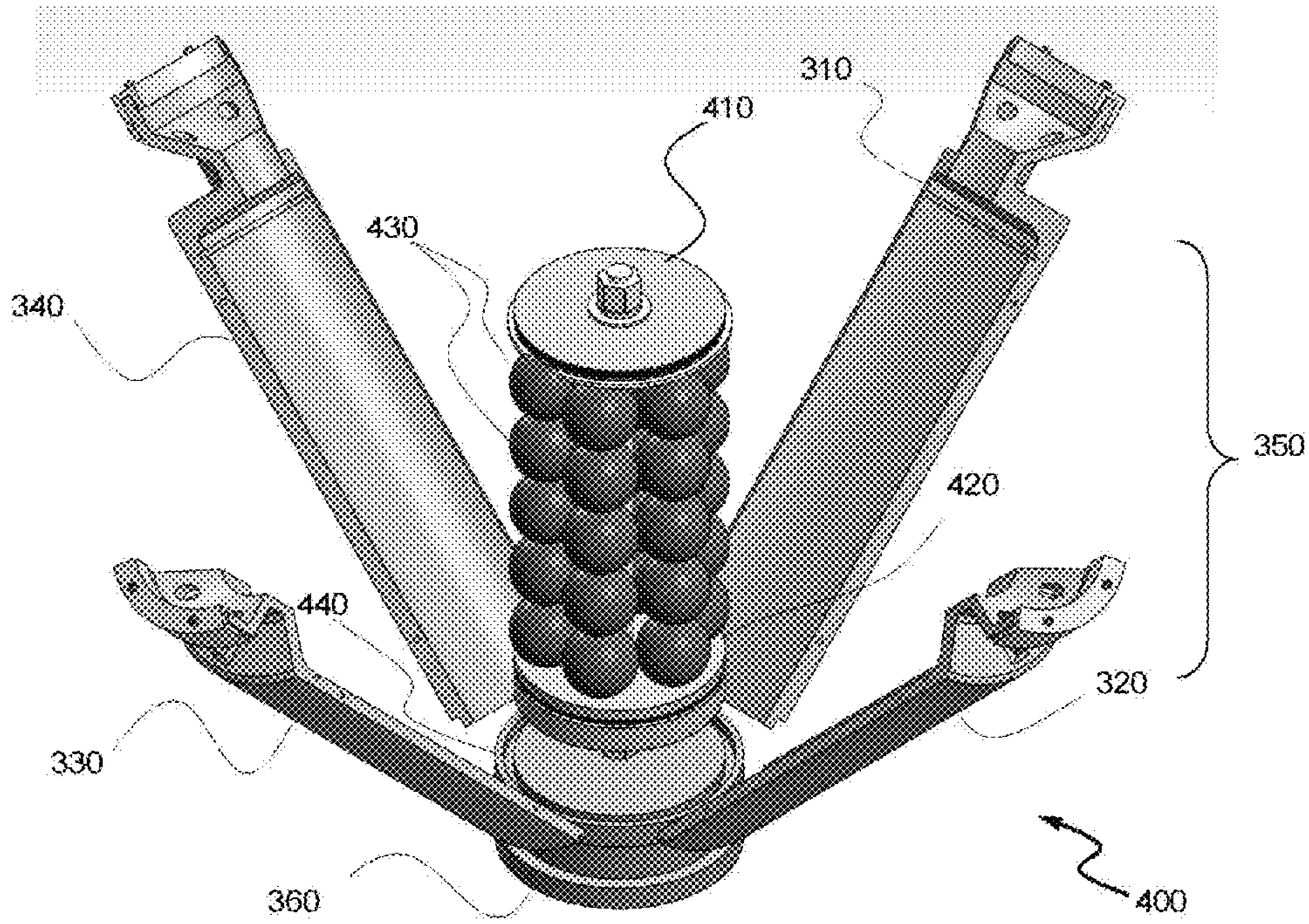

310
410
430
340
350
420
440
320
330
360
400

FIG. 4

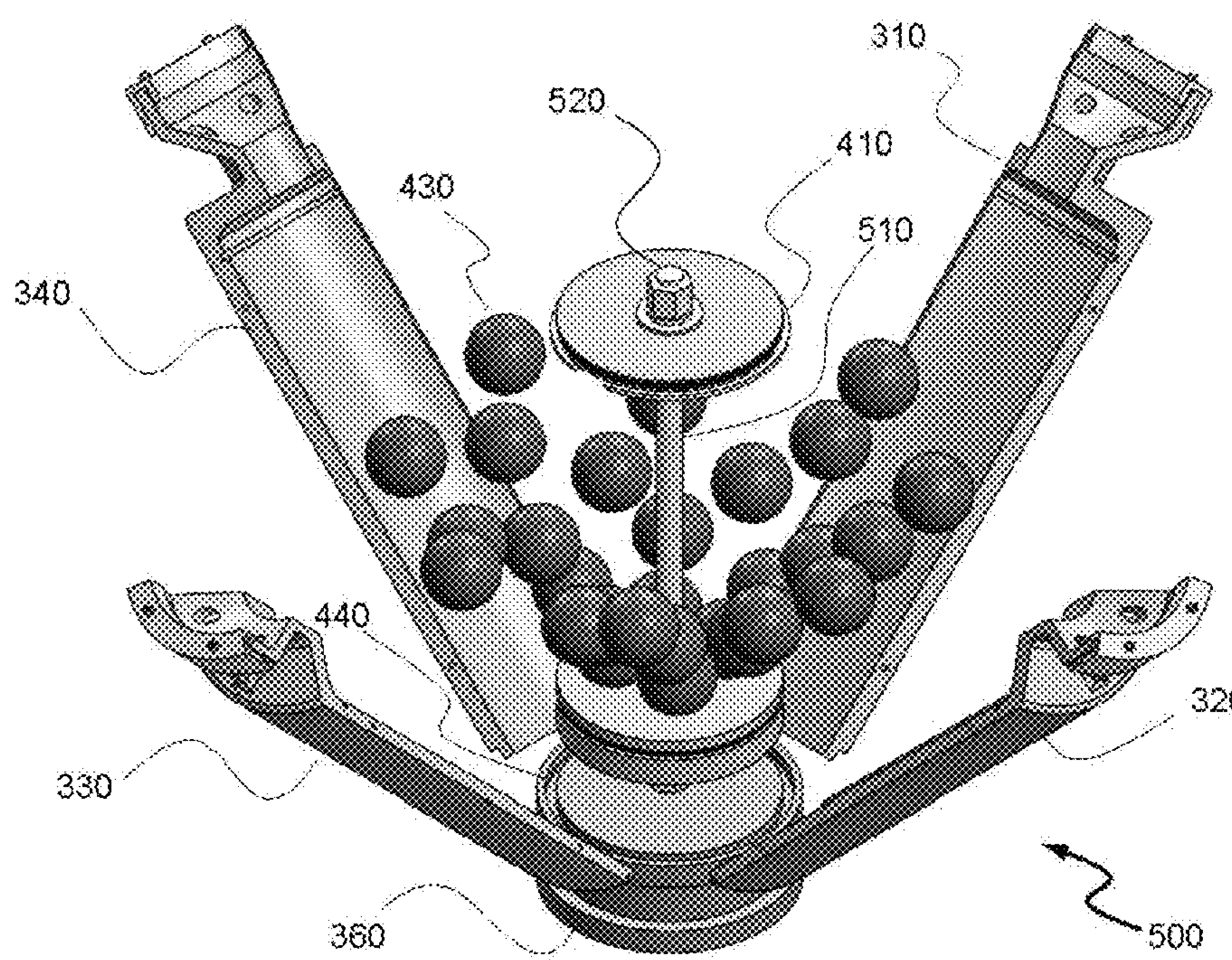

310
520
410
430
510
340
440
320
330
360
500

FIG. 5

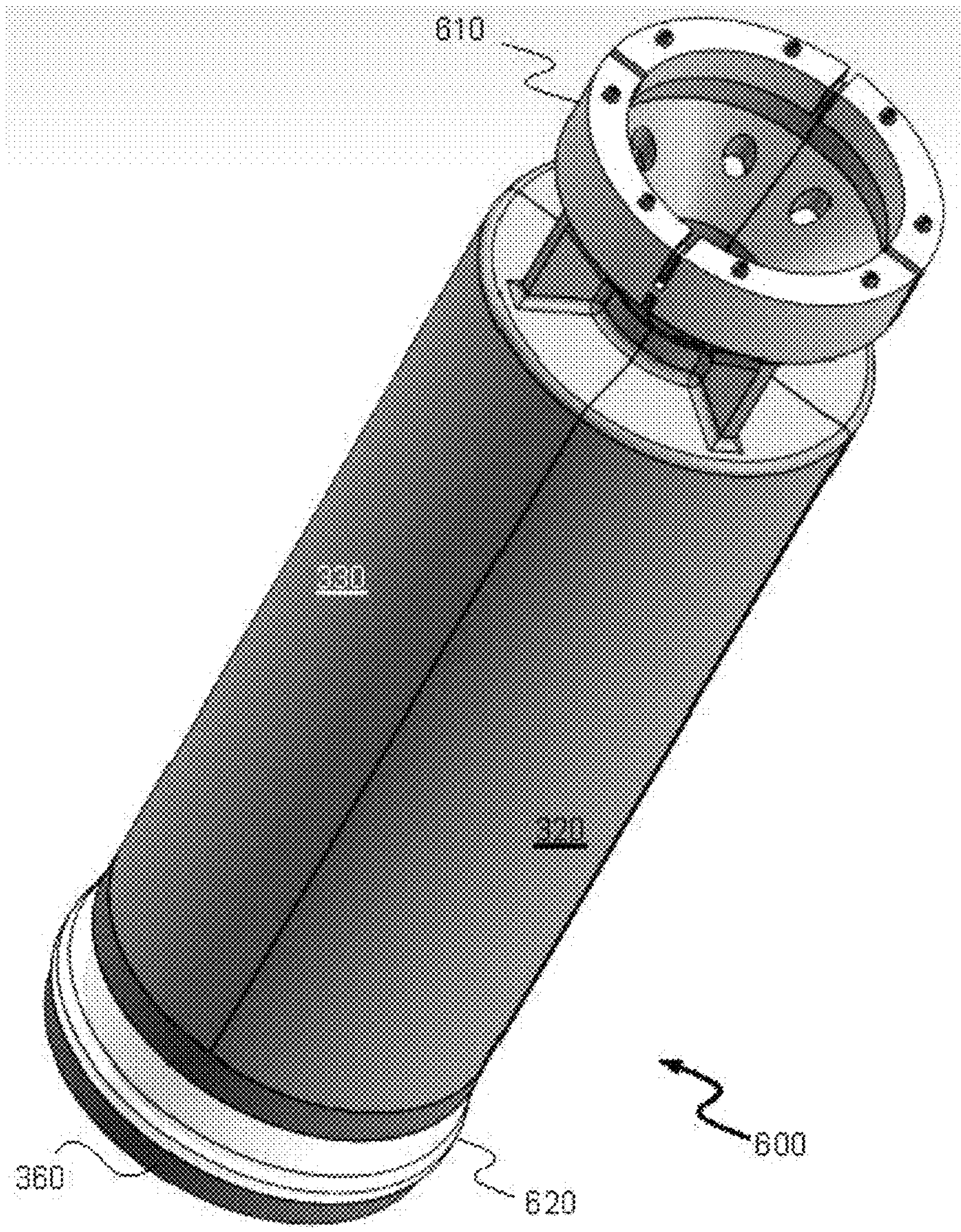


FIG. 6

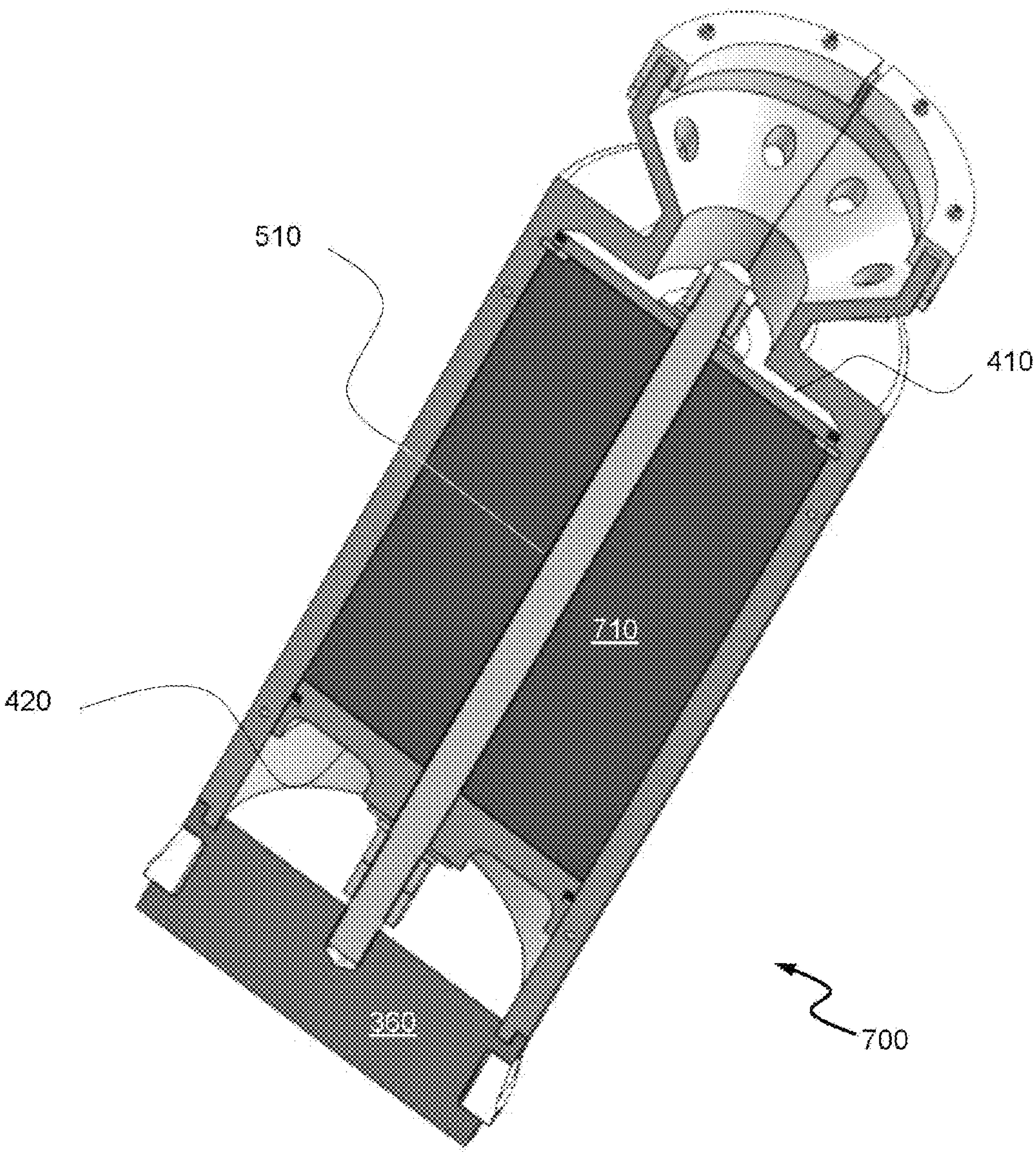


FIG. 7

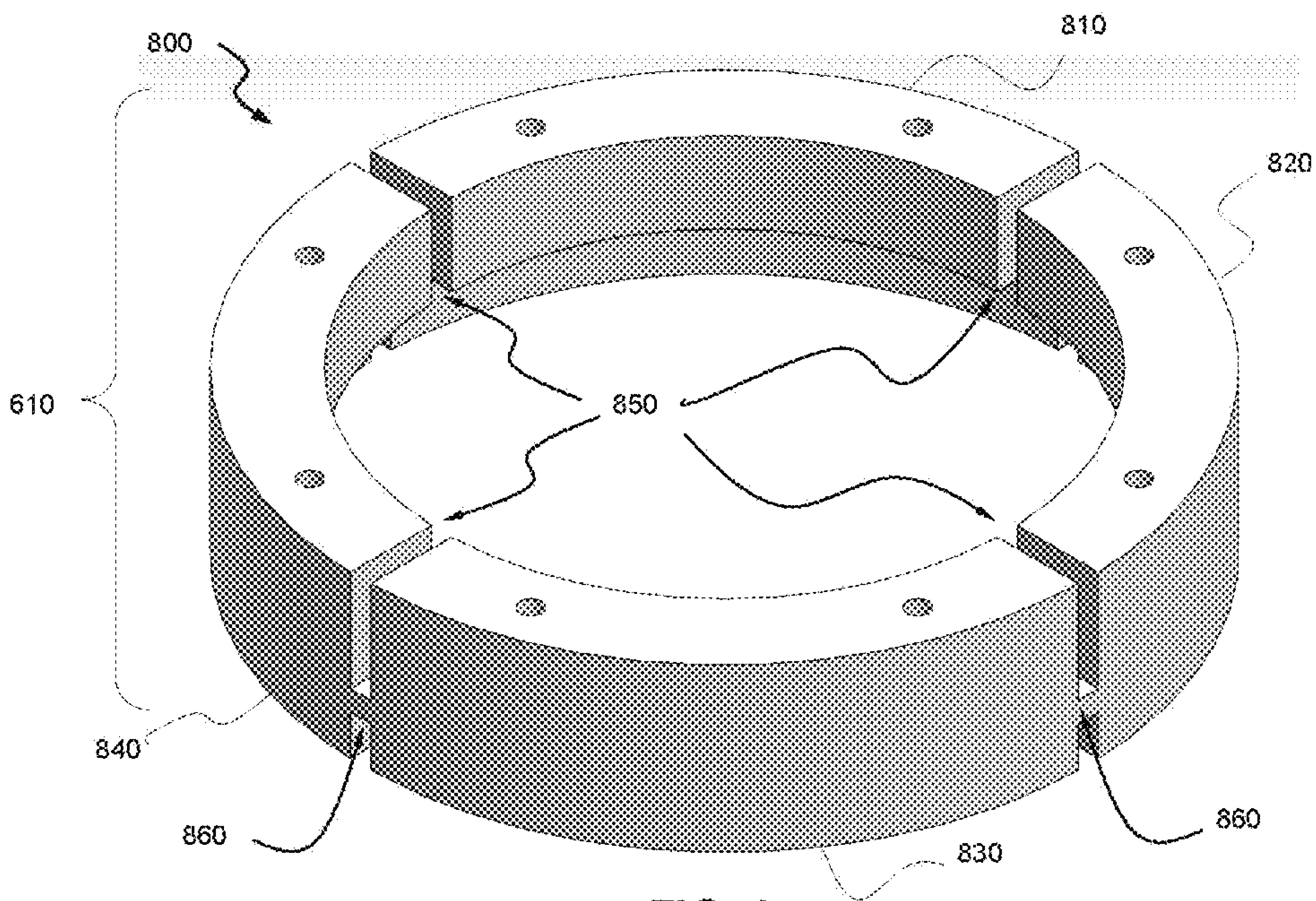


FIG. 8

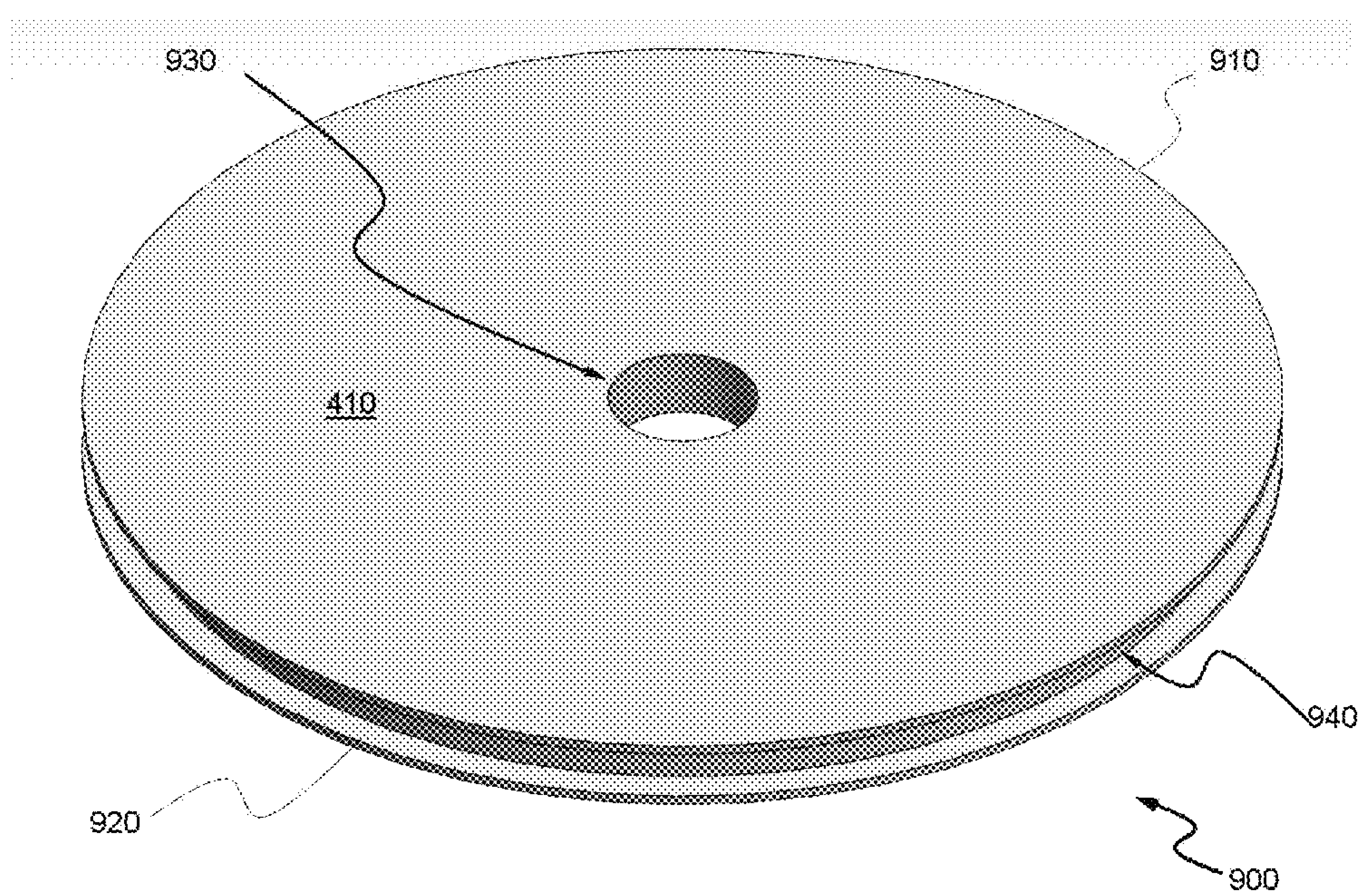


FIG. 9

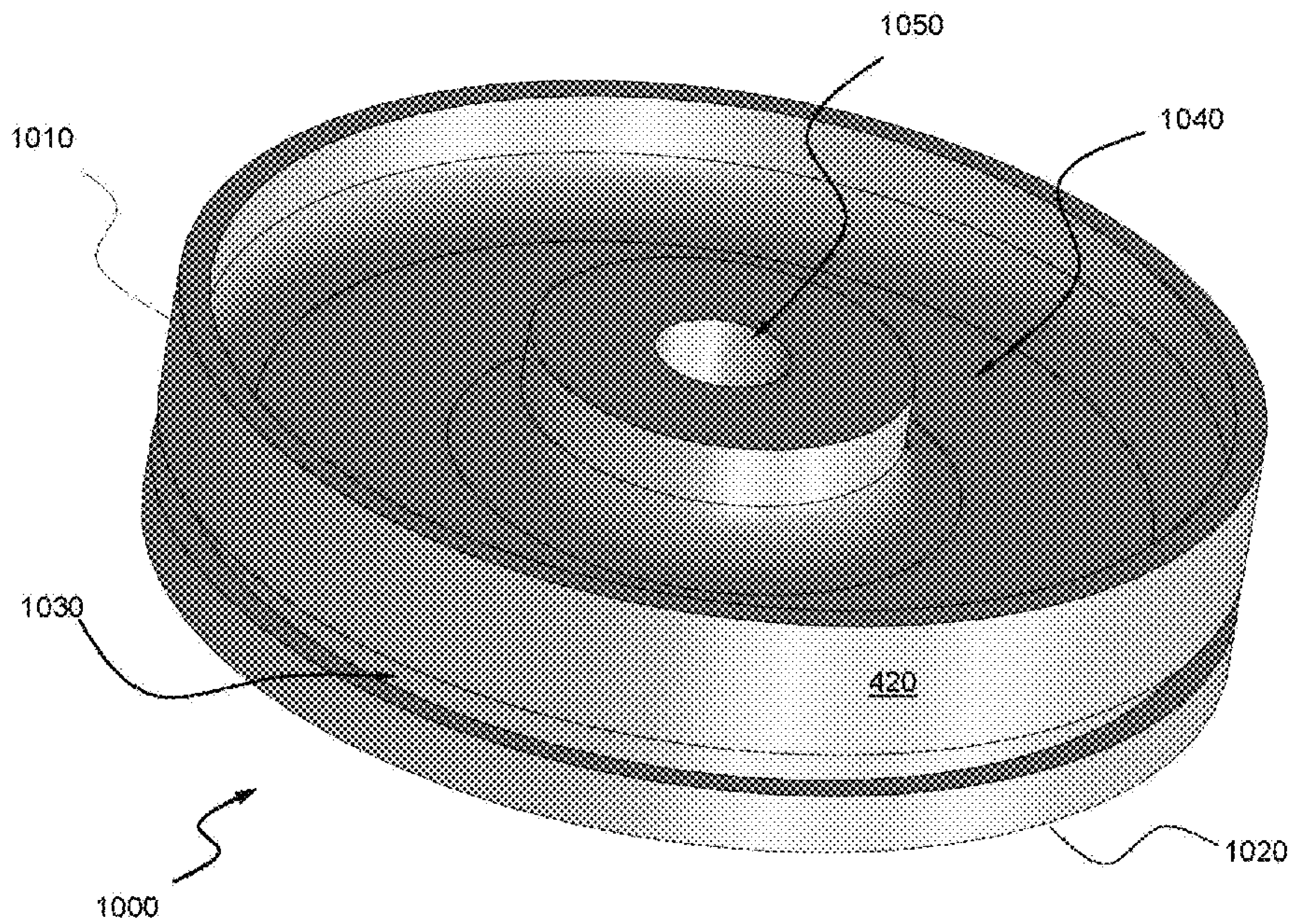


FIG. 10

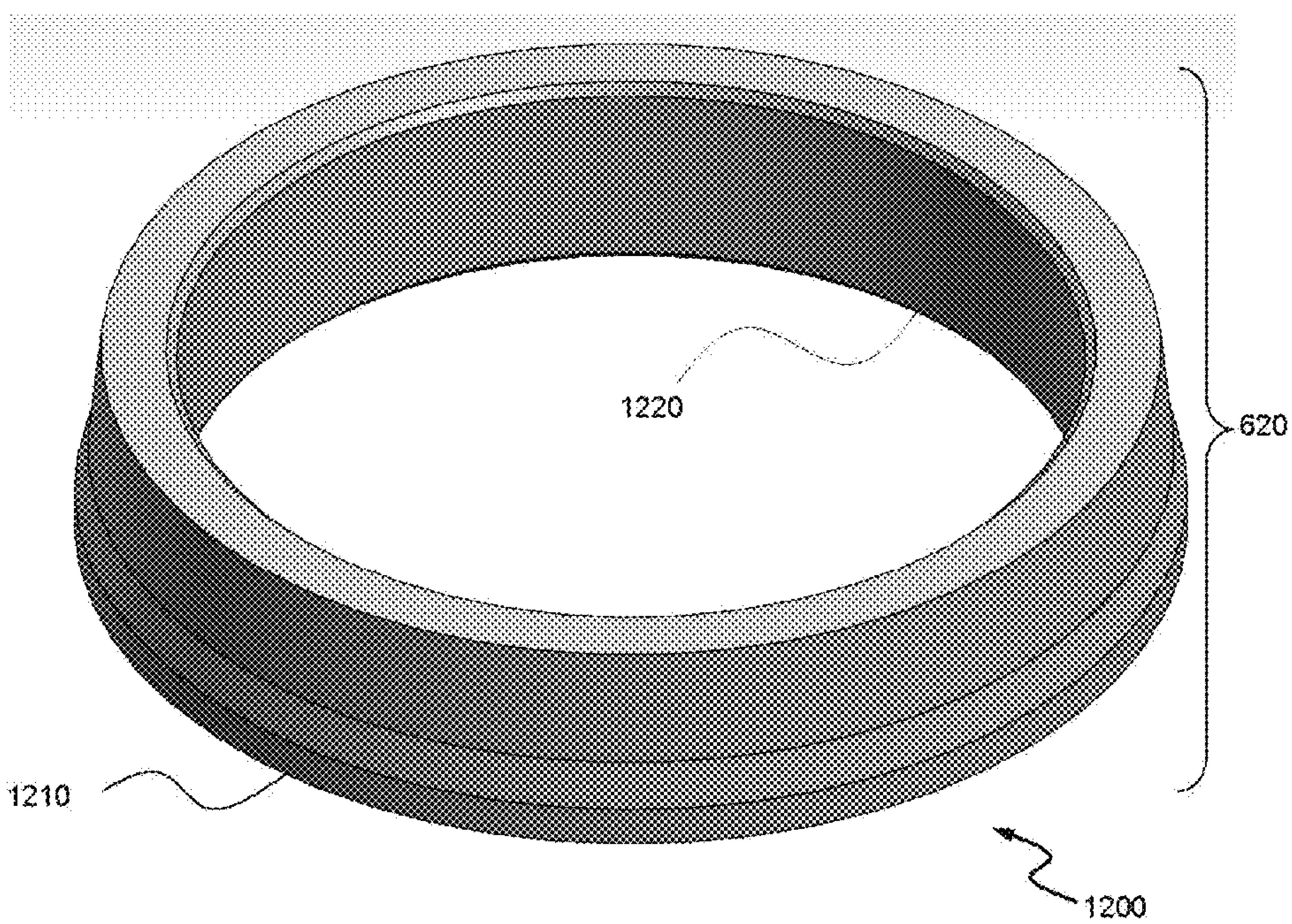


FIG. 12

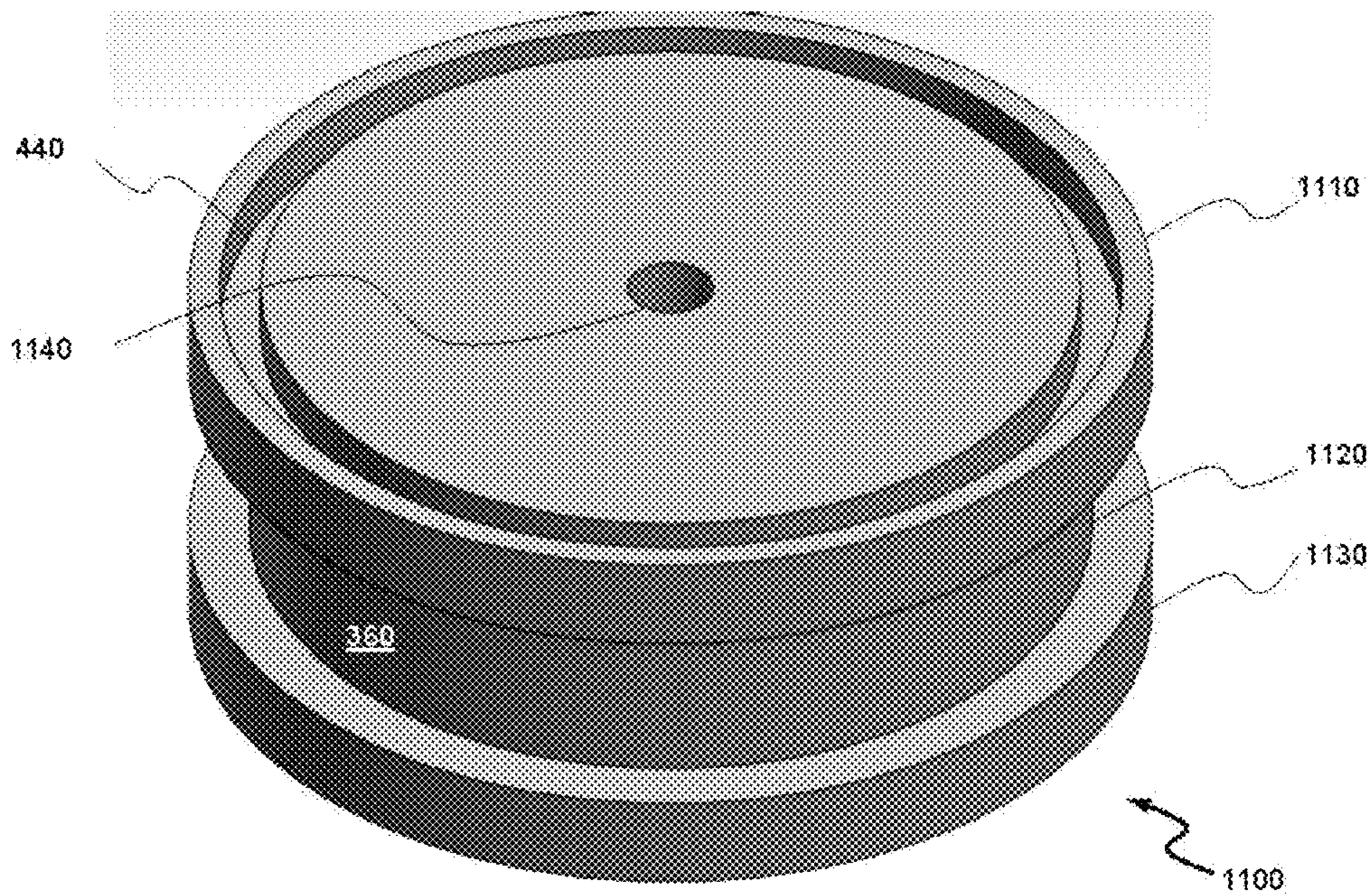


FIG. 11A

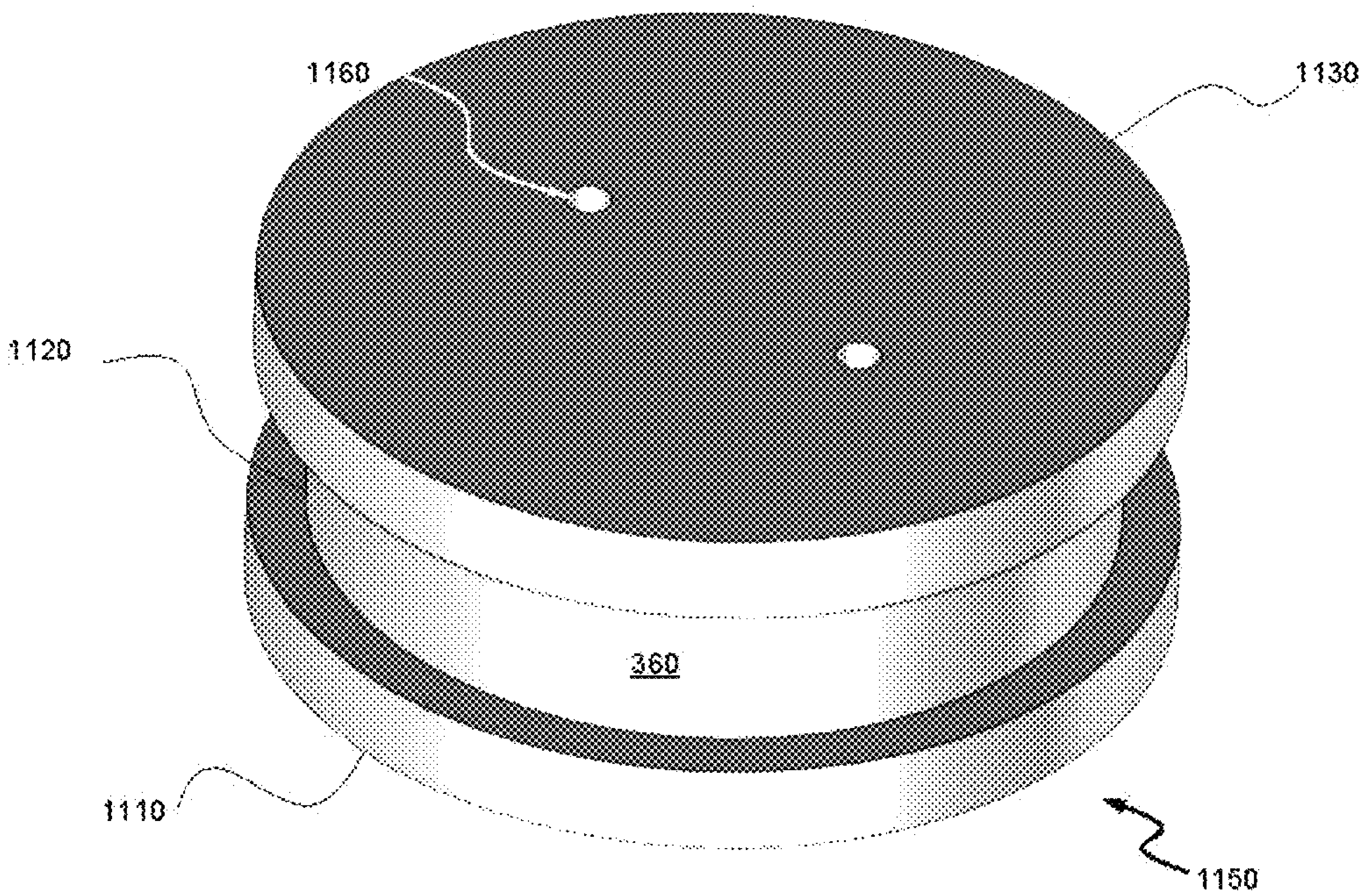


FIG. 11B

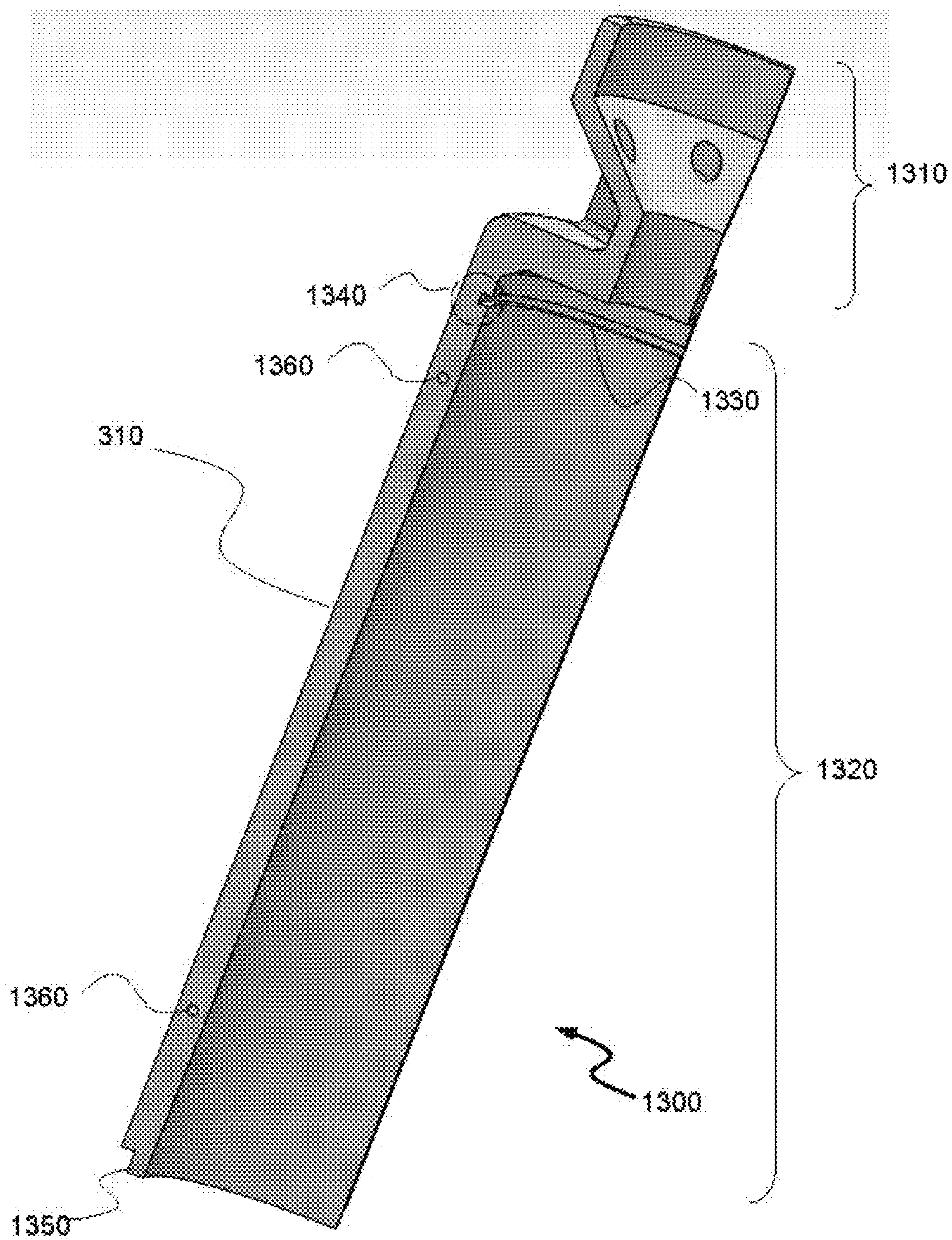


FIG. 13

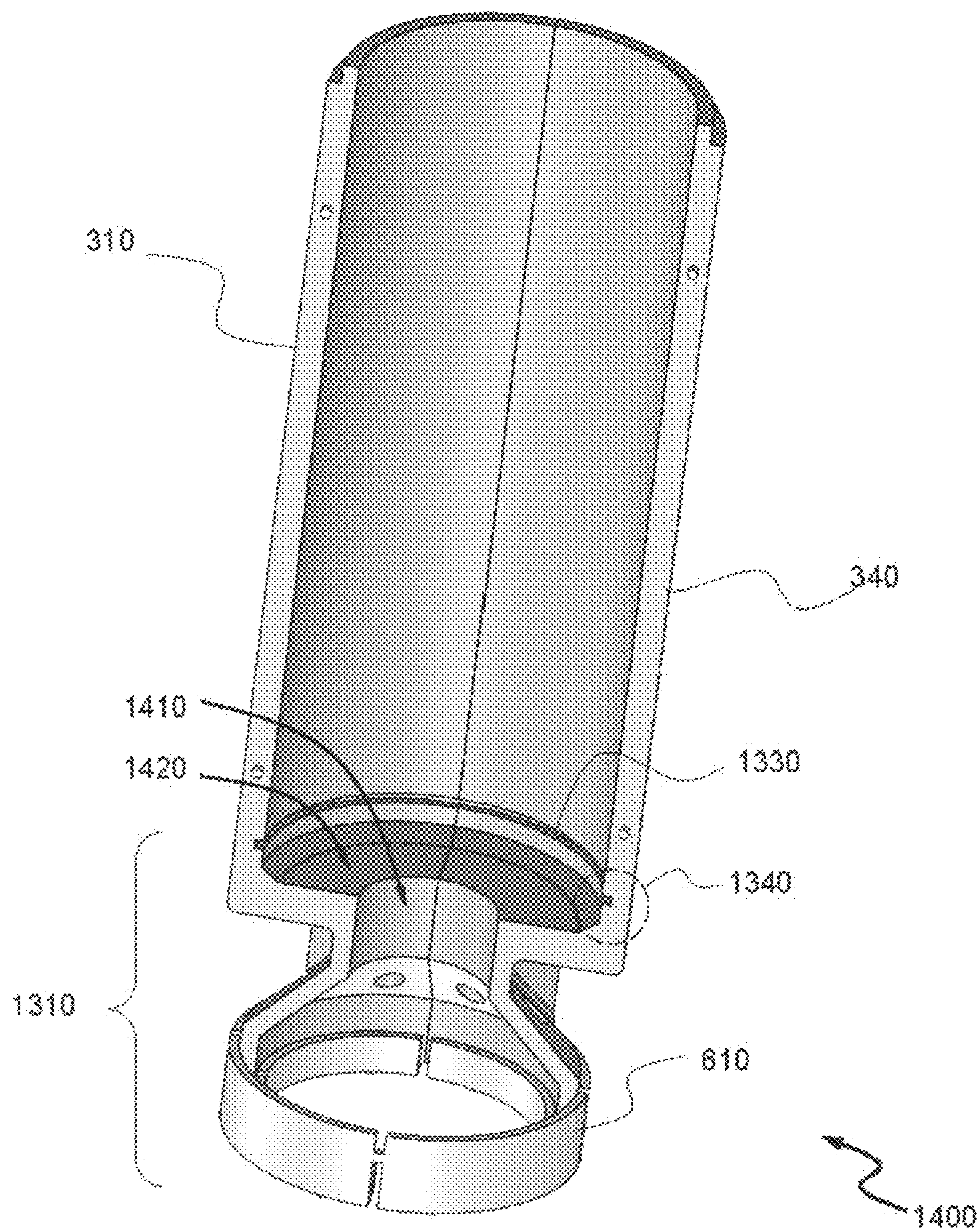


FIG. 14A

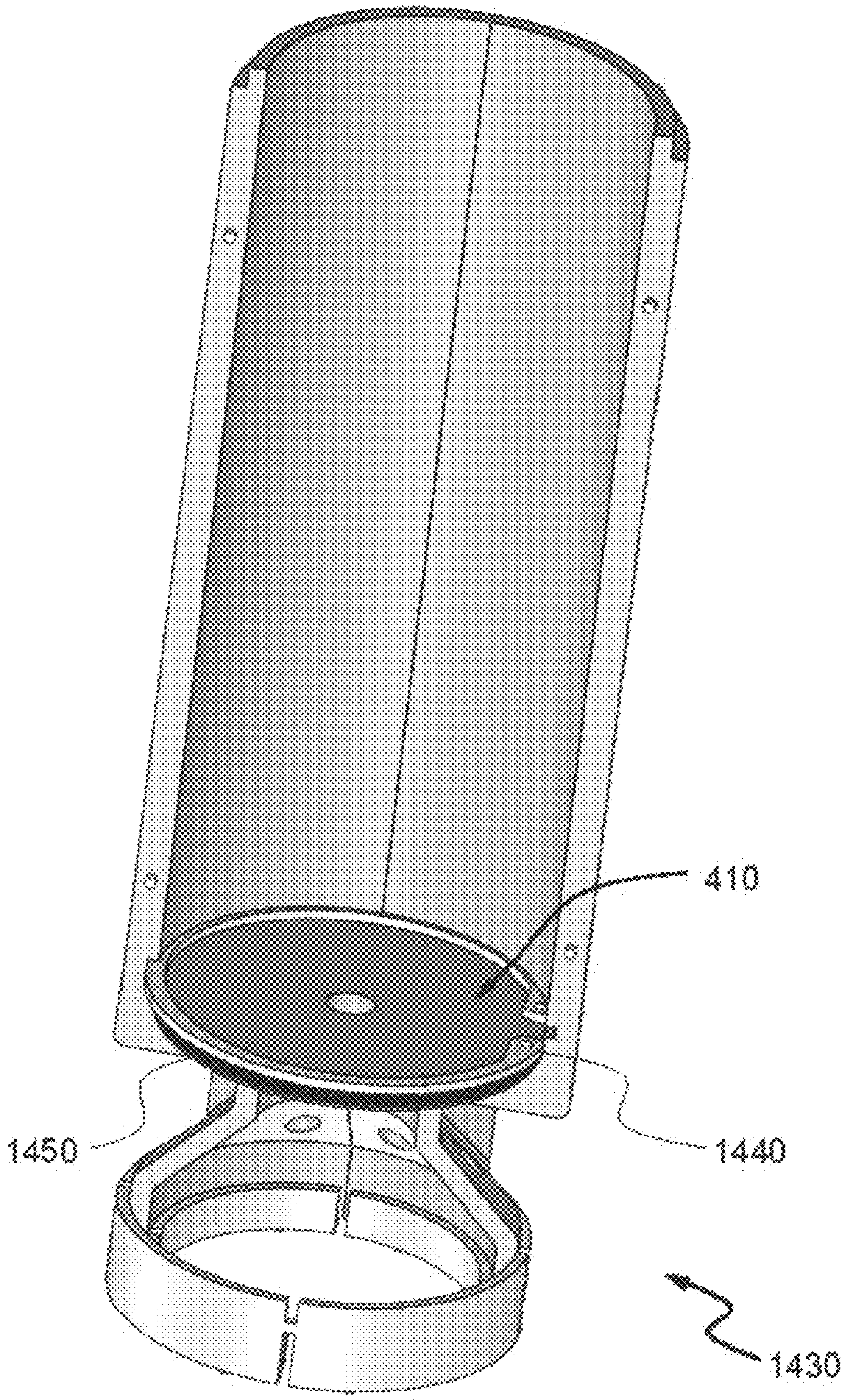


FIG. 14B

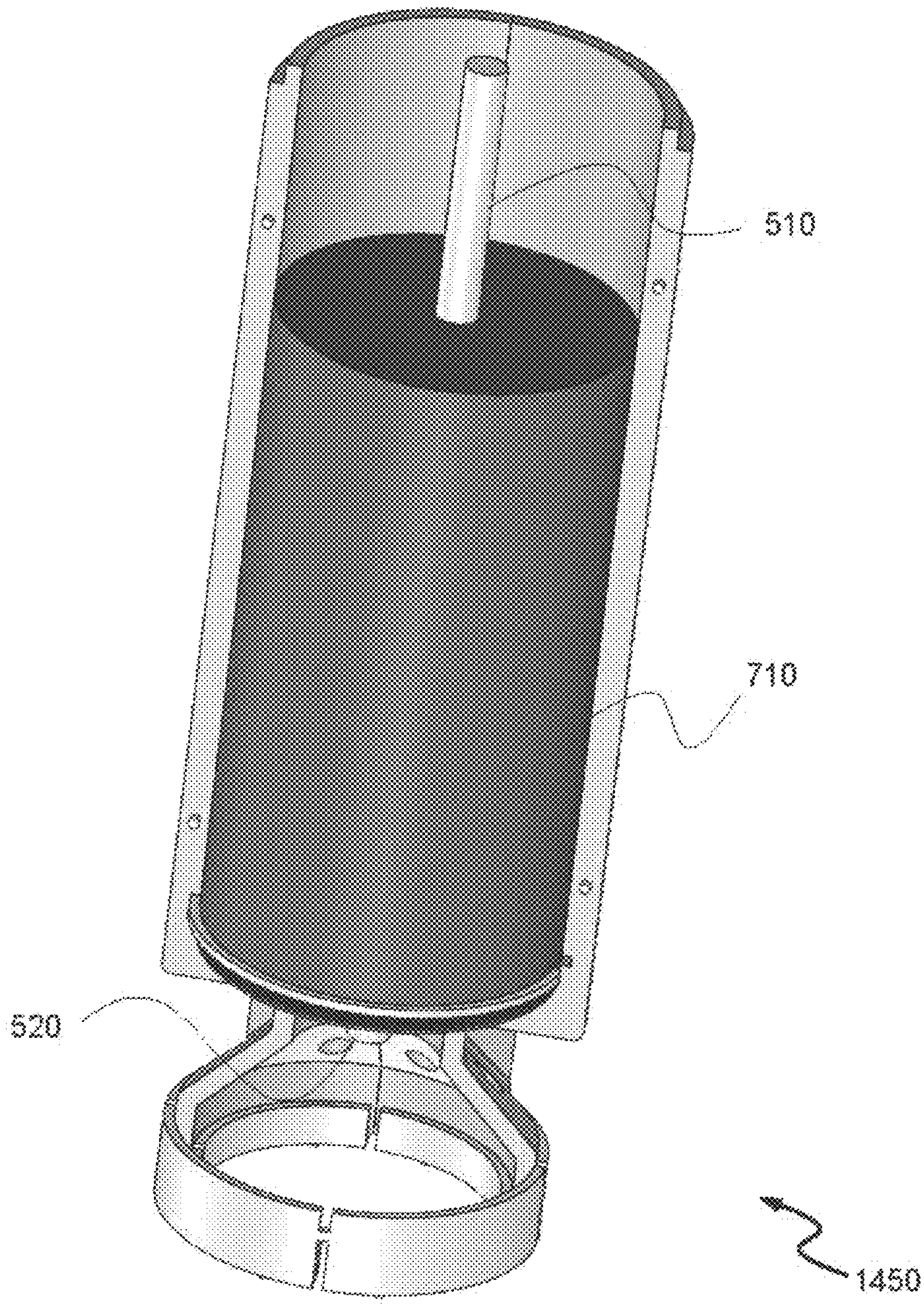
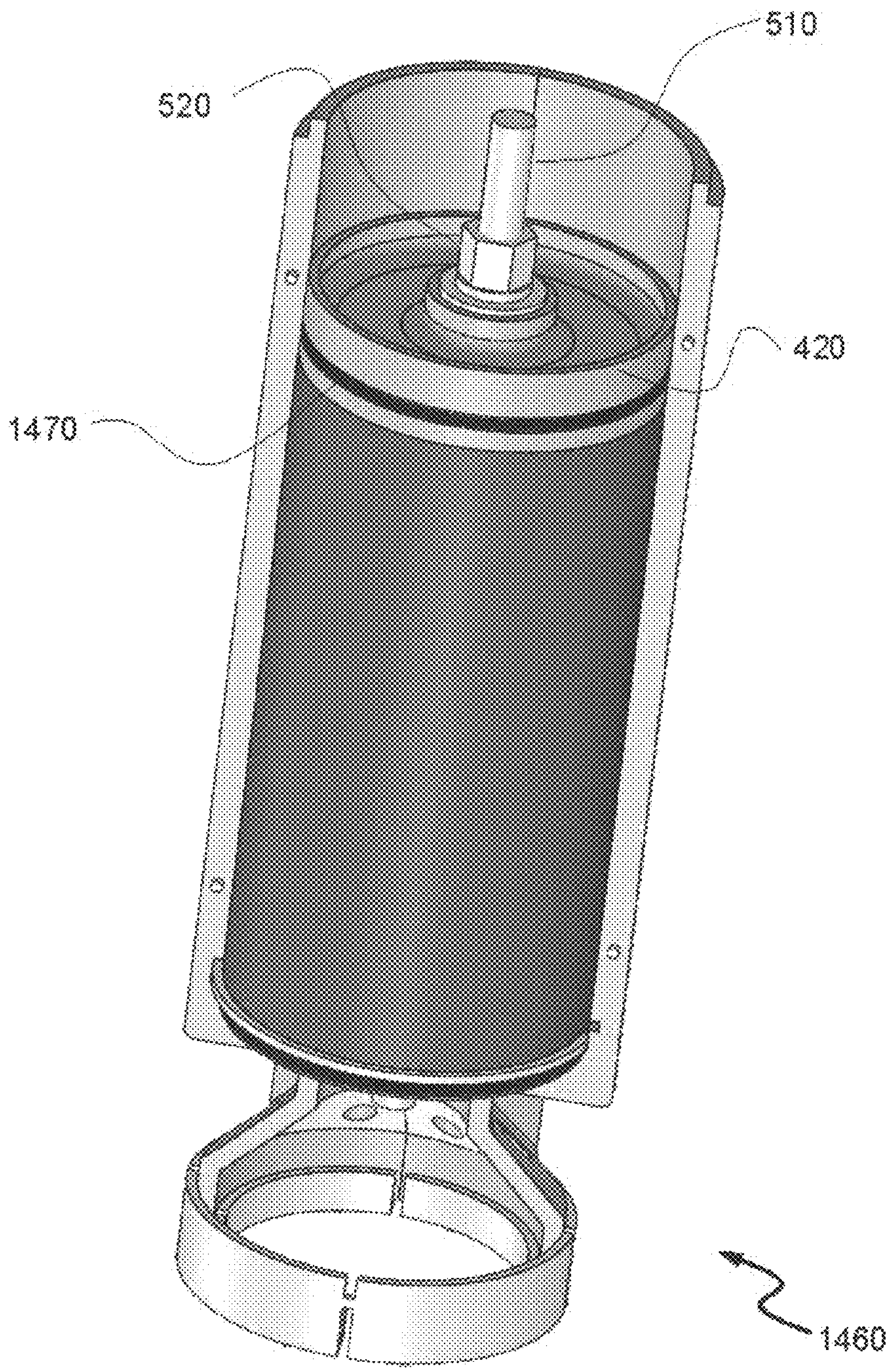


FIG. 14C



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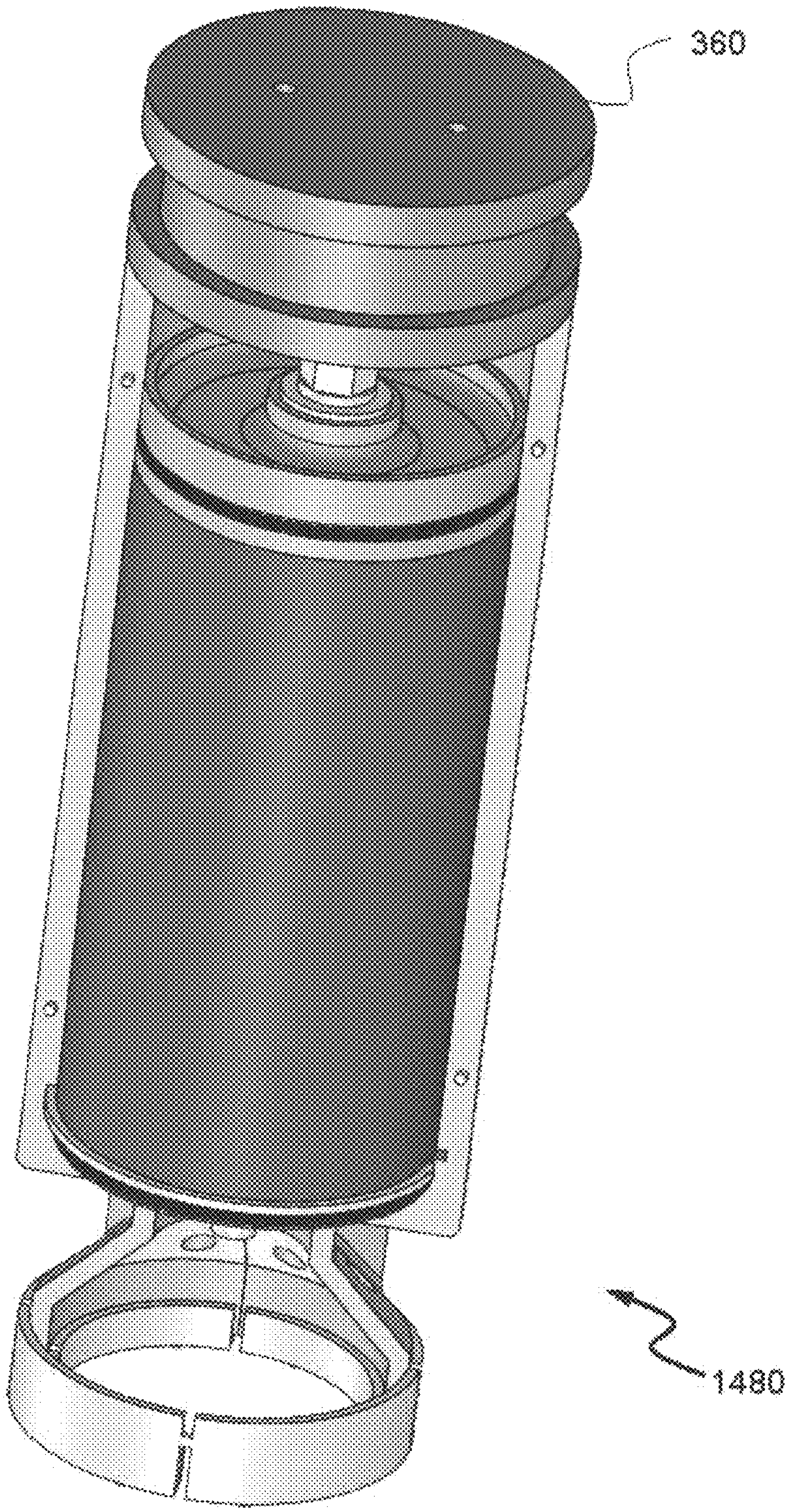

FIG. 14E

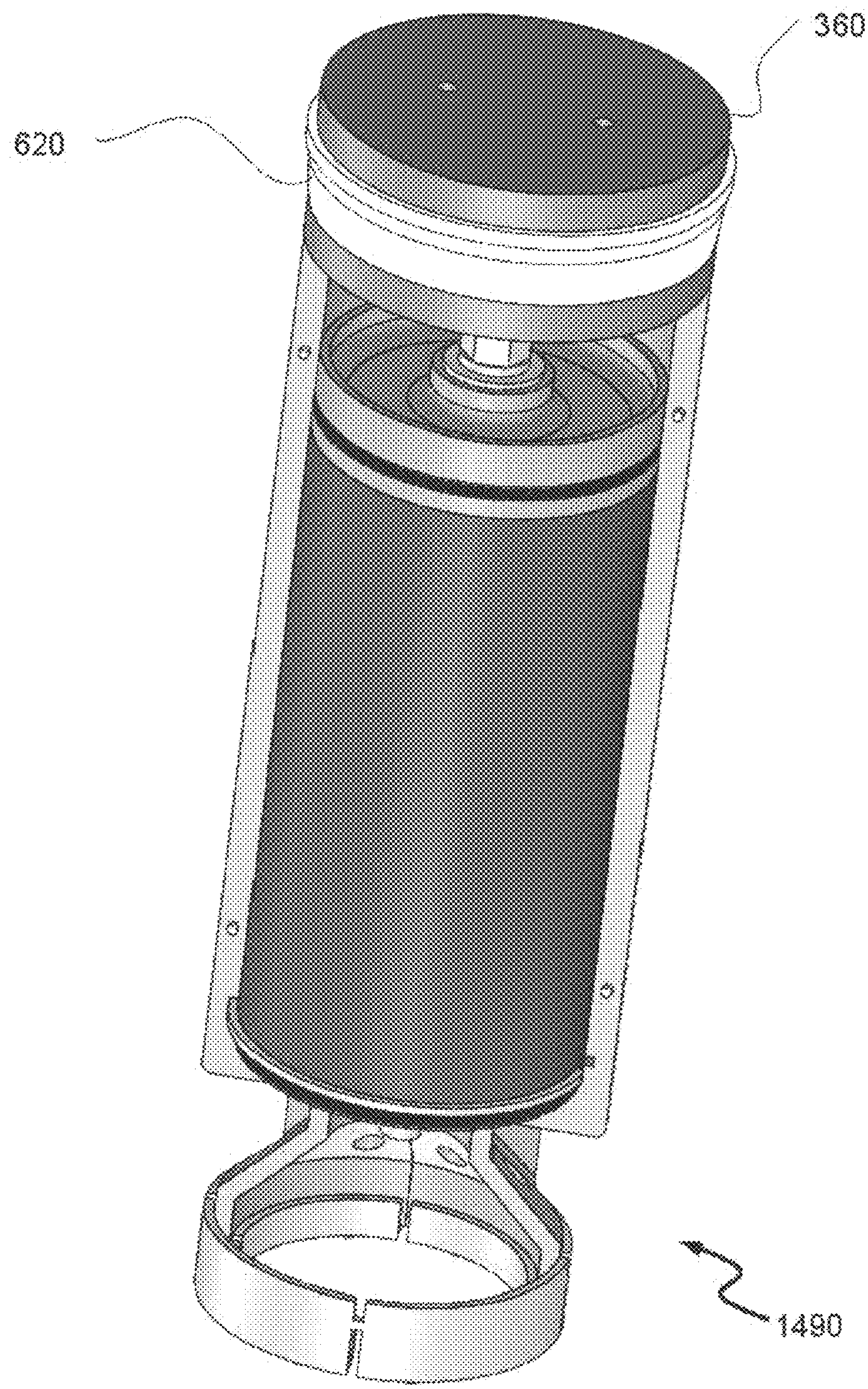

FIG. 14F

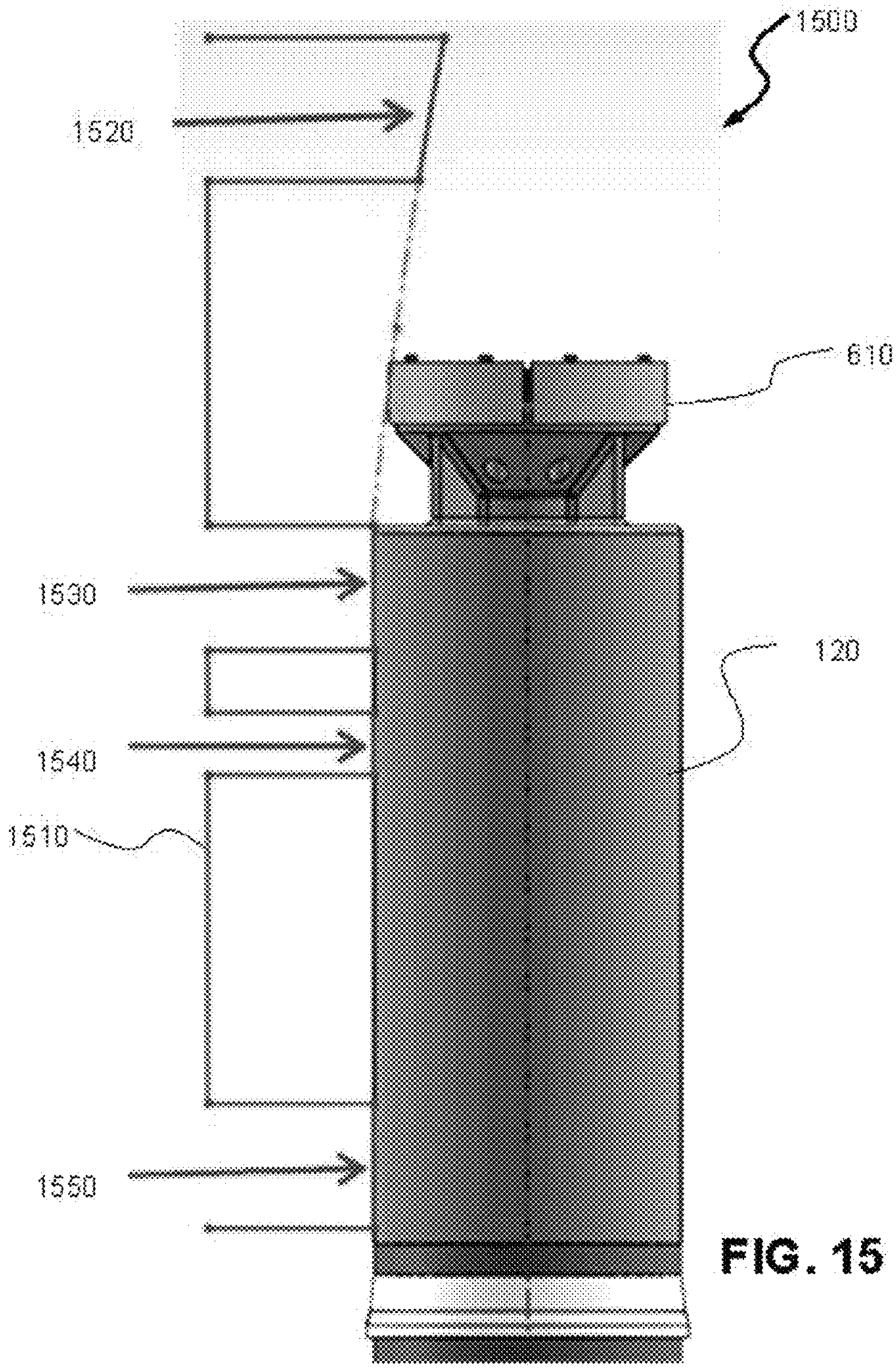

FIG. 15

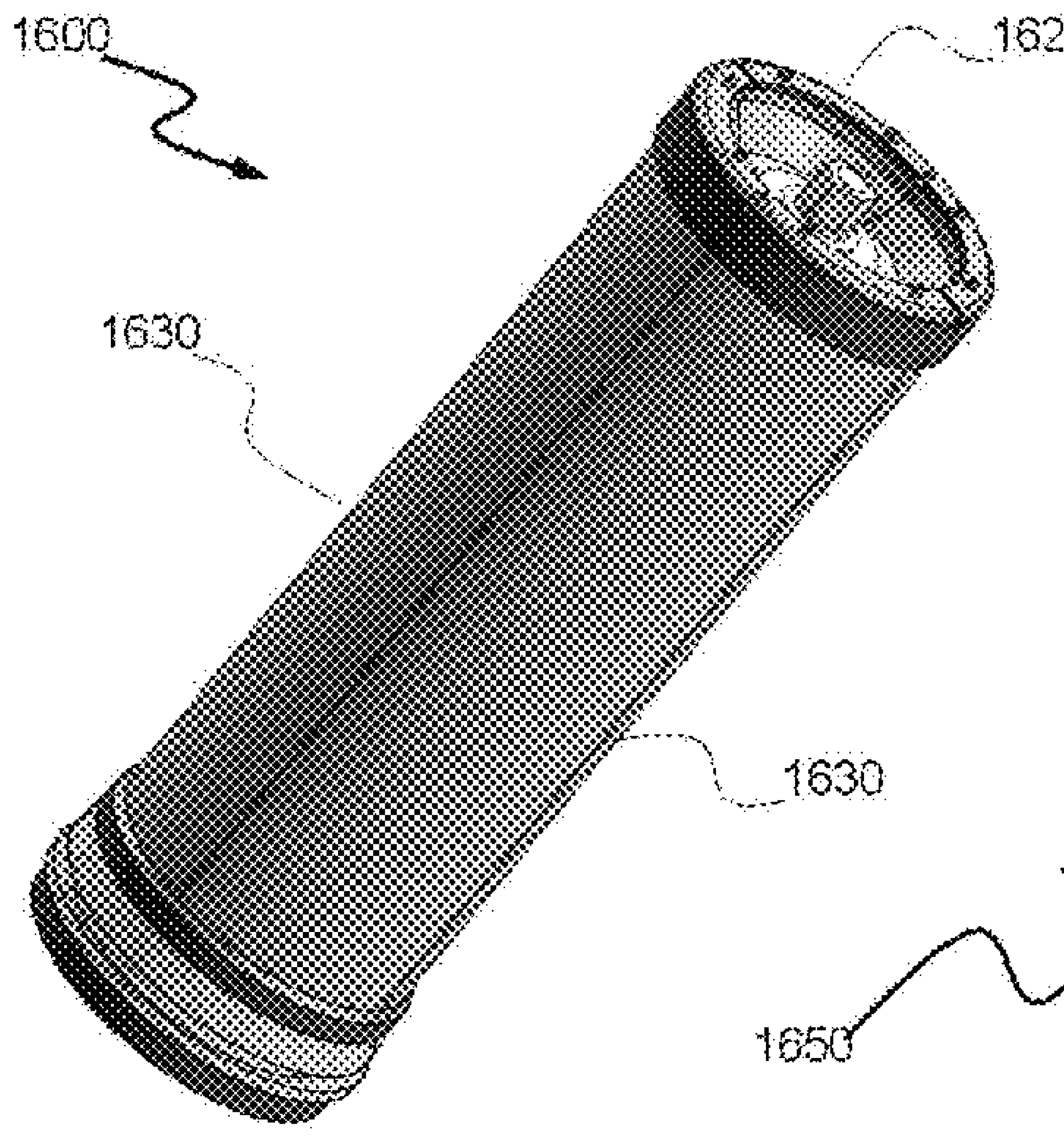

FIG. 16A

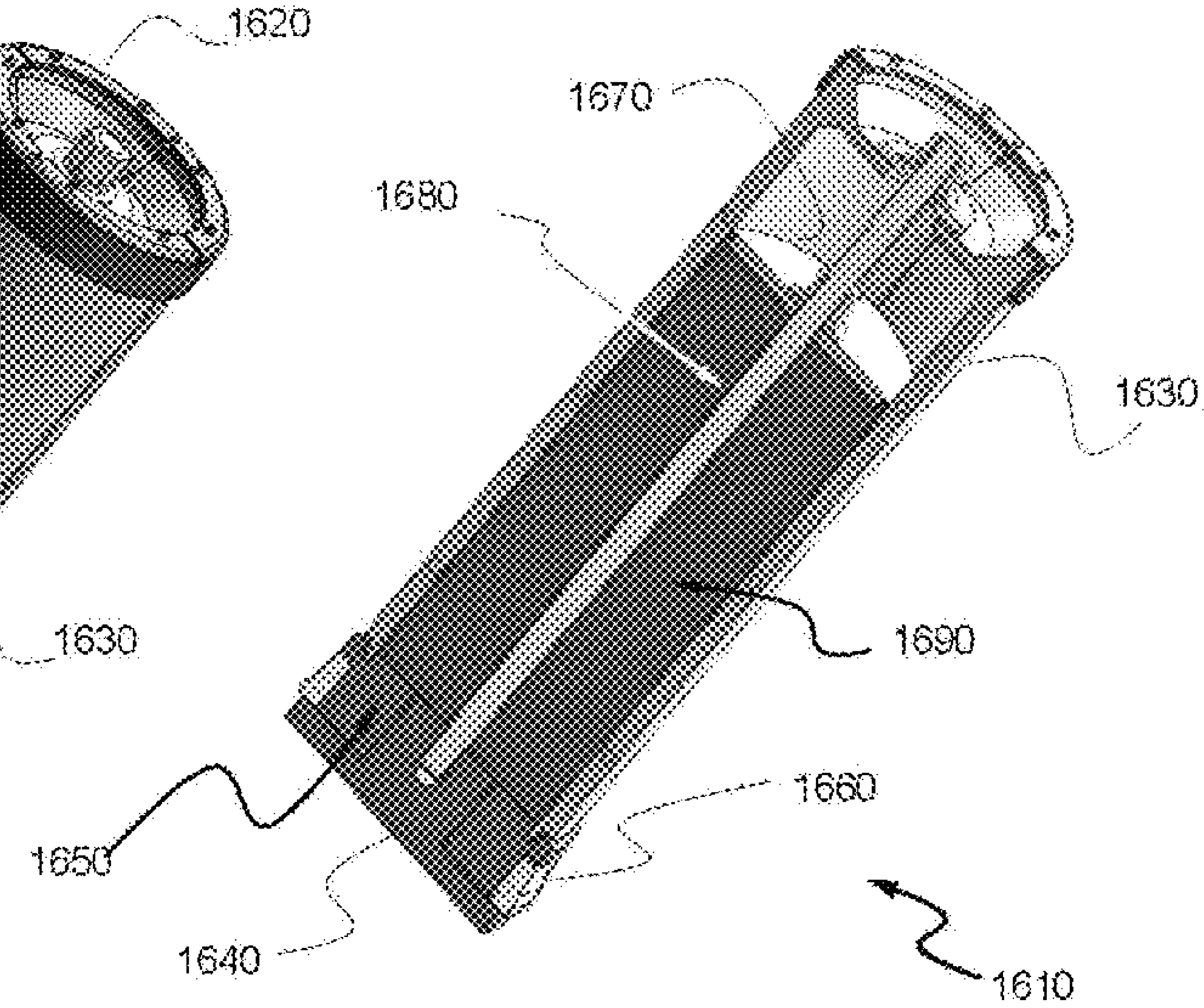

FIG. 16B

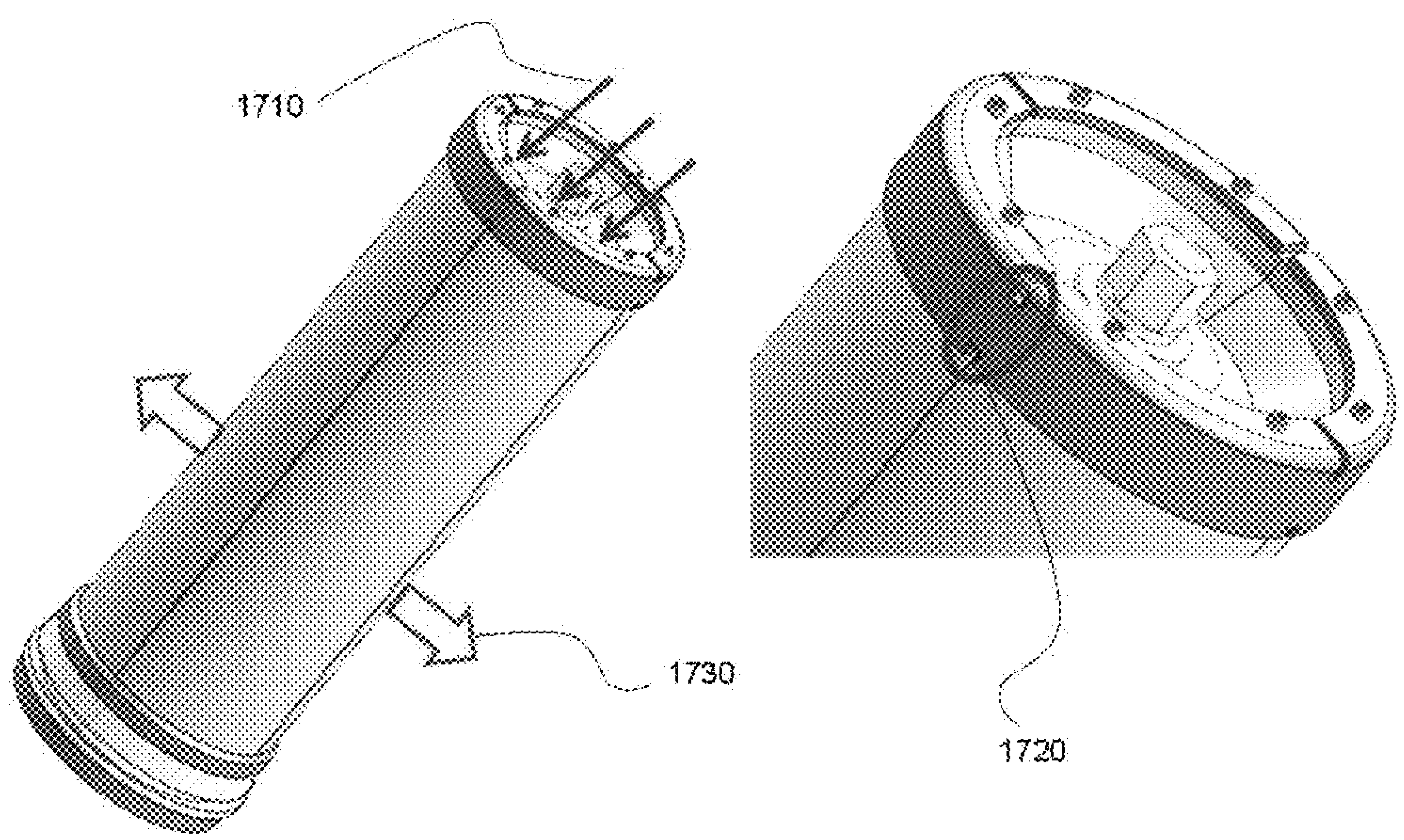

FIG. 17

1700

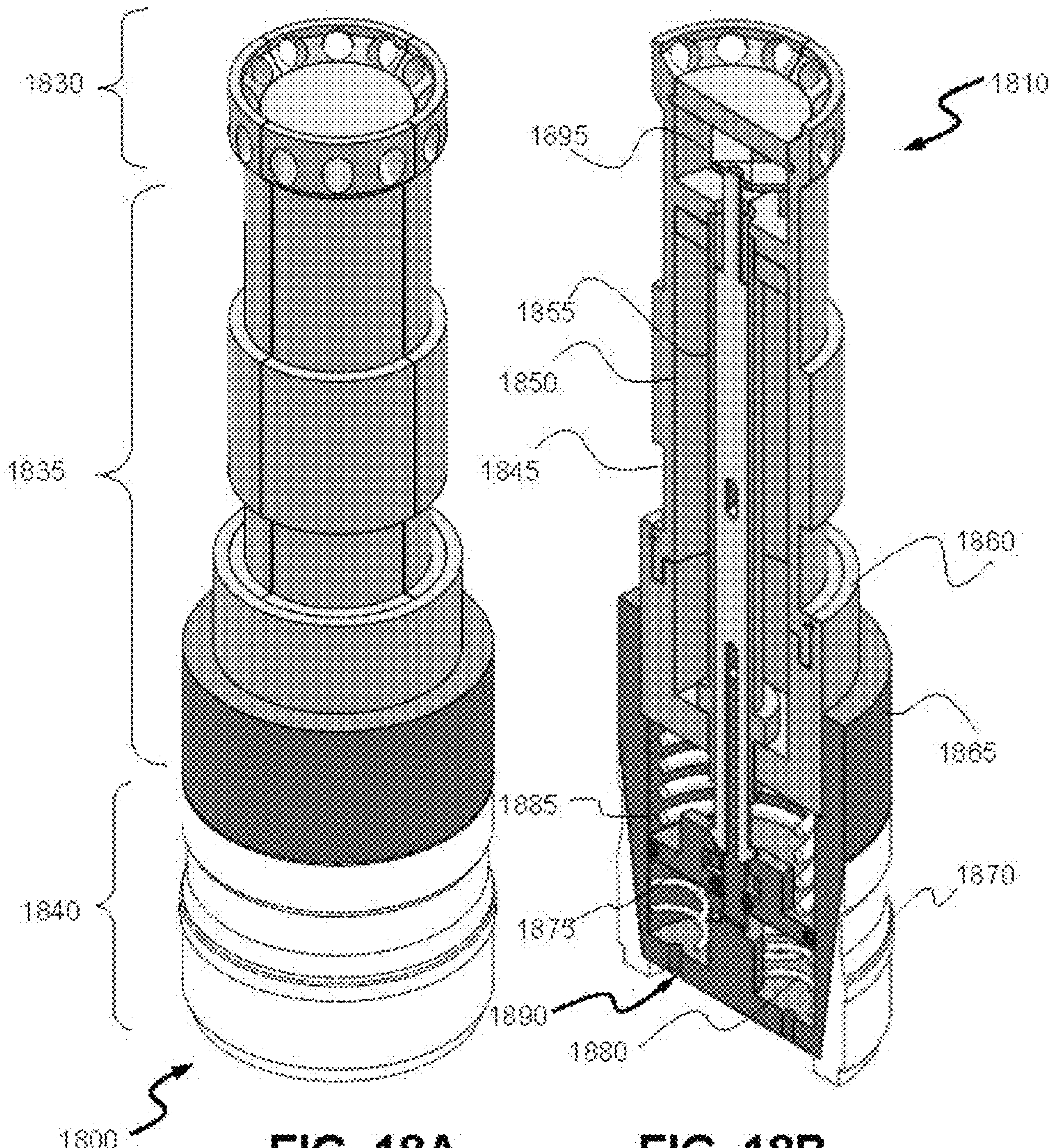

FIG. 18A FIG. 18B

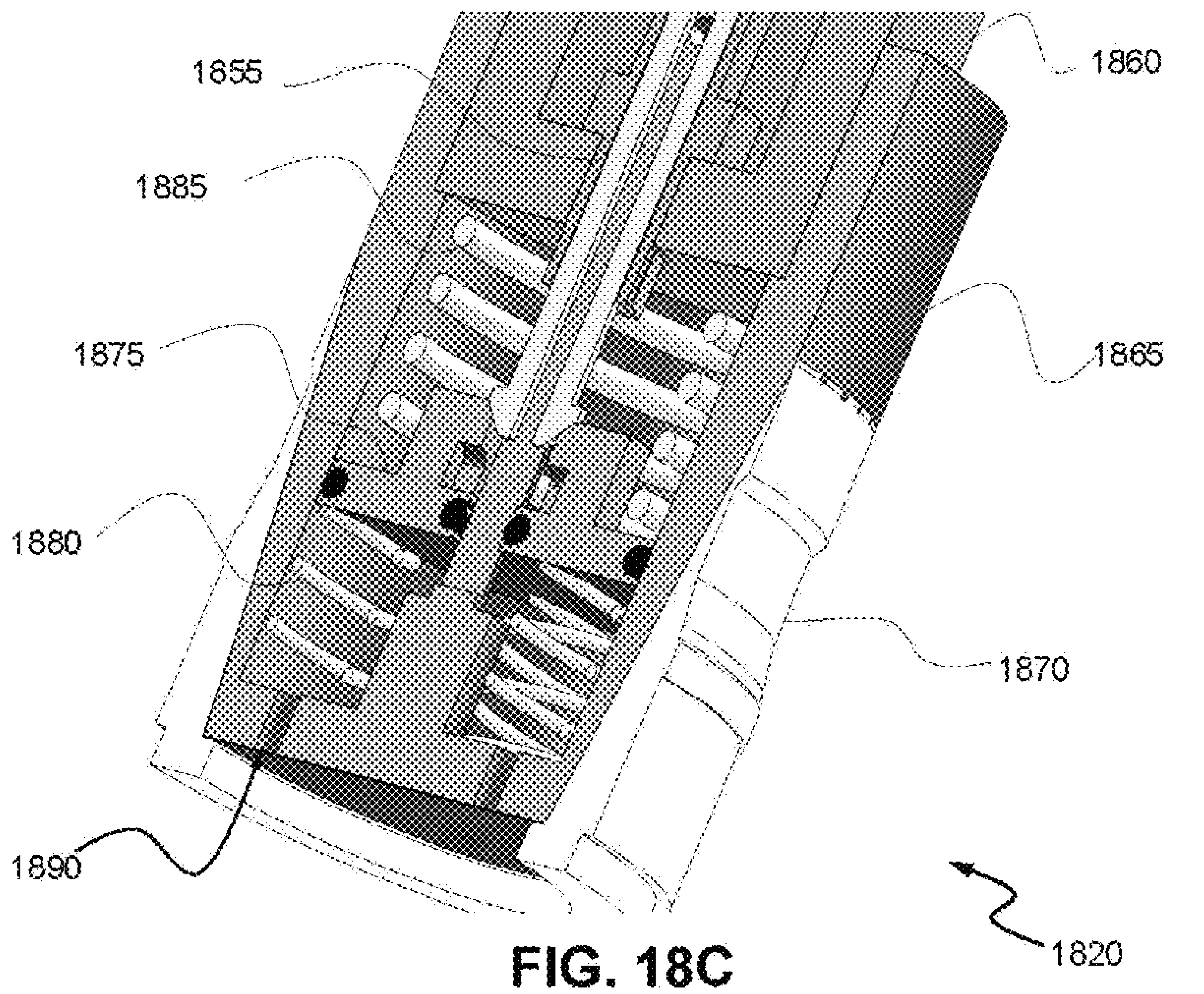

FIG. 18C

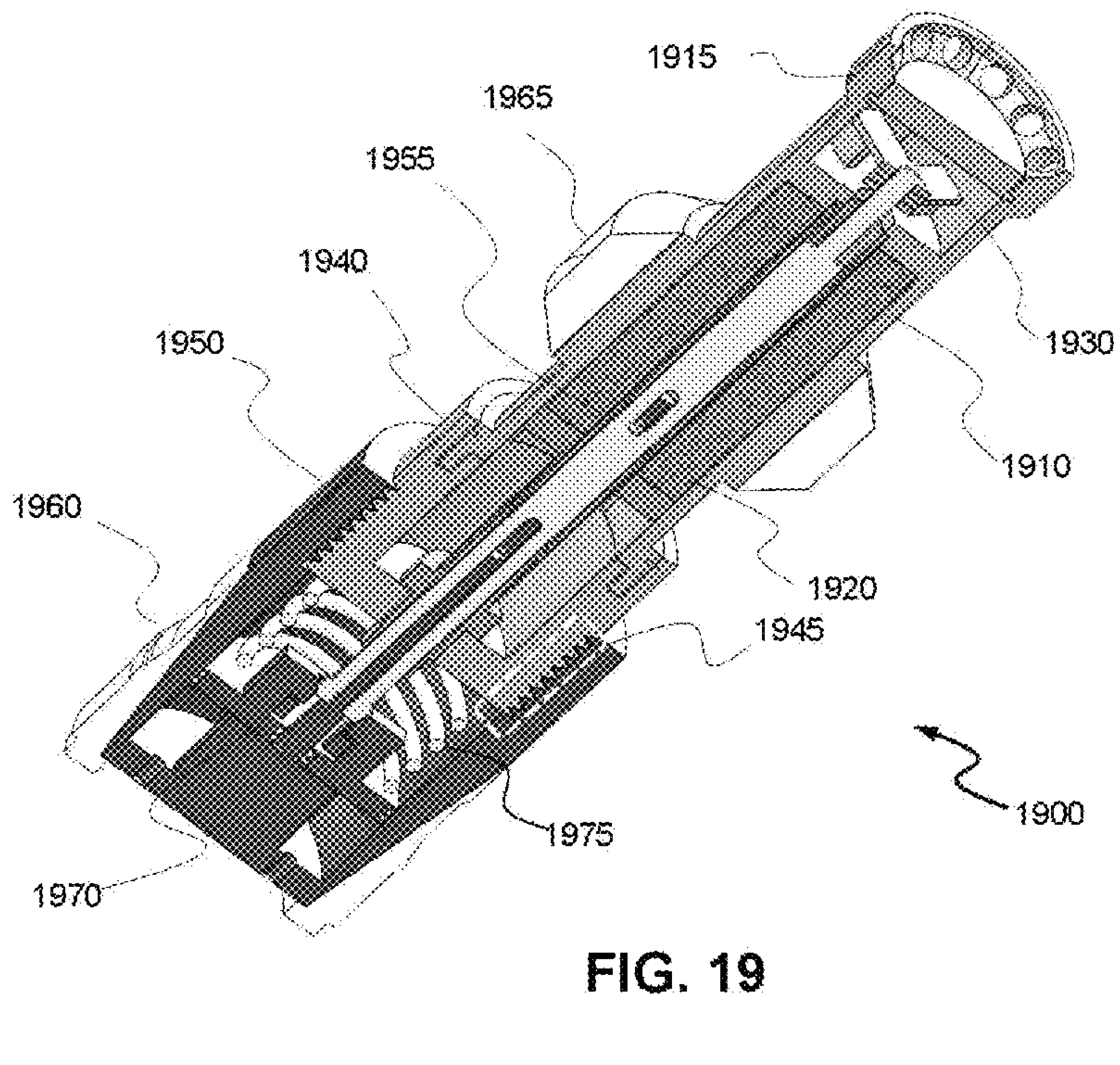

FIG. 19

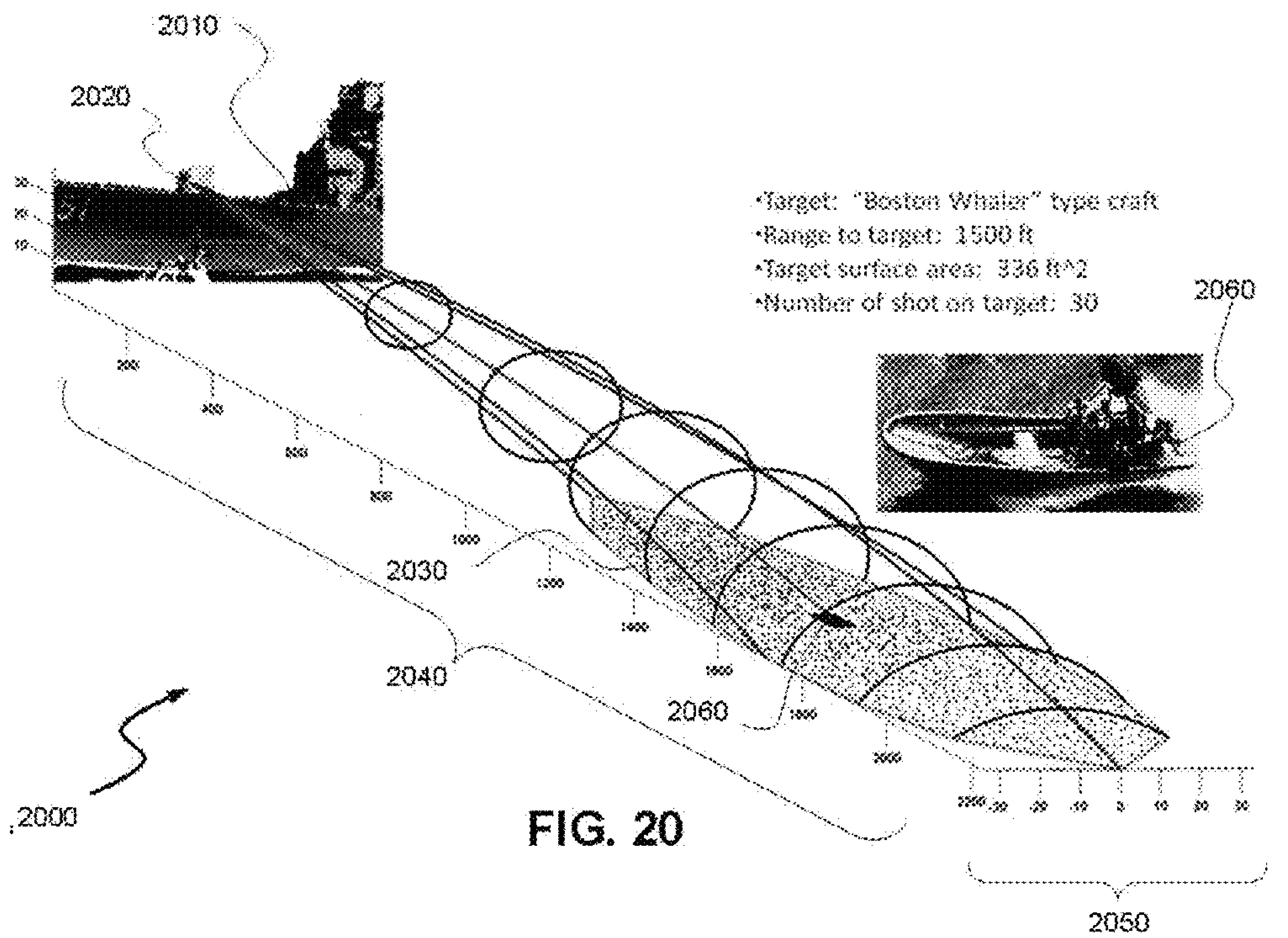
2010
2020
•Target: "Boston Whaler" type craft
•Range to target: 1500 ft
•Target surface area: 336 ft^2
•Number of shot on target: 30
2060
2030
2040
2060
2000
2050

FIG. 20

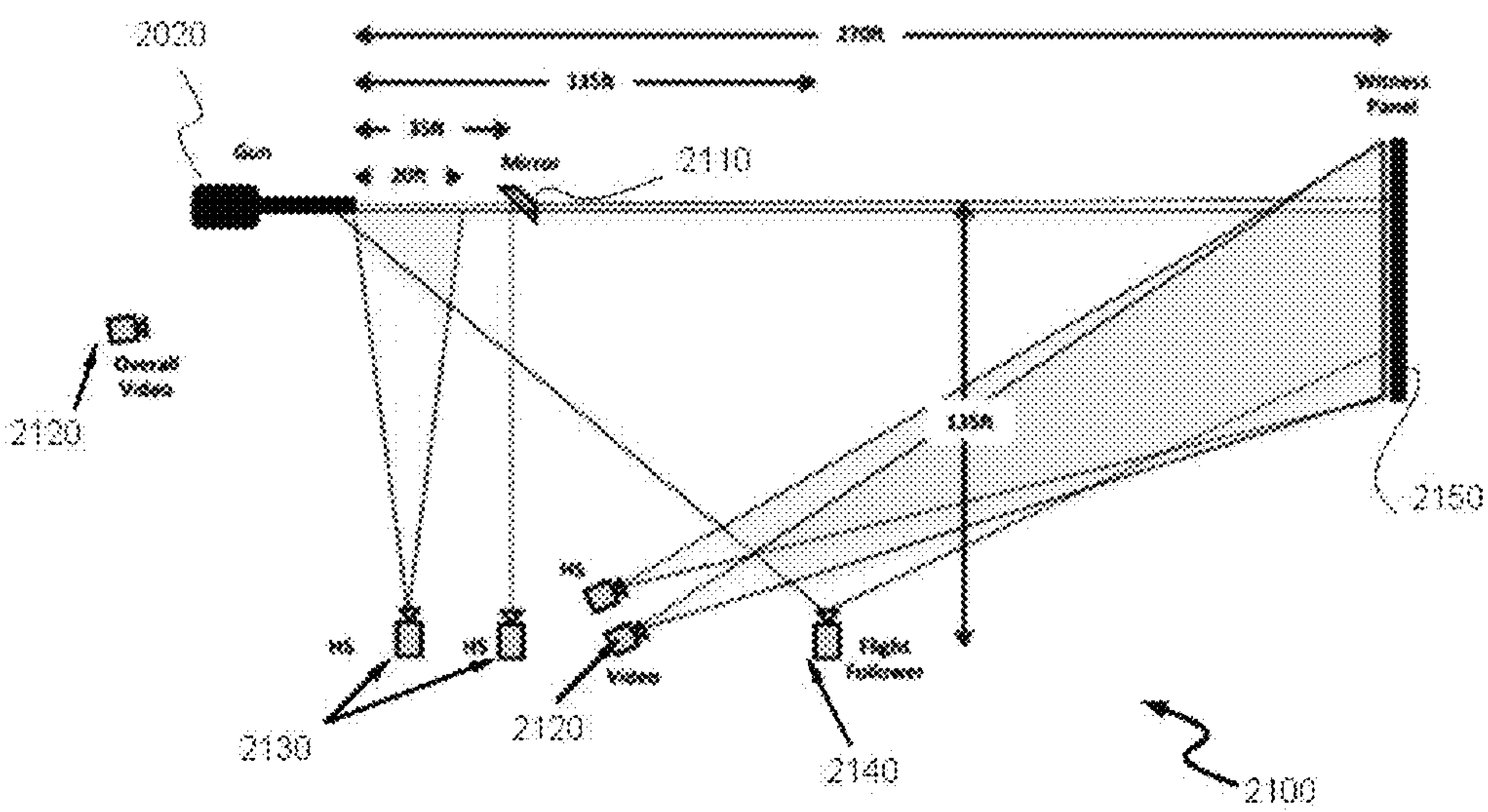
2020
Gun
Mirror
2110
Witness Panel
2120
Overall Video
2150
HS
HS
HS
Video
Flight Follower
2130
2120
2140
2100

FIG. 21

INERT AND PRESSURE-ACTUATED SUBMUNITIONS DISPENSING PROJECTILE

STATEMENT OF GOVERNMENT INTEREST

The invention described was made in the performance of official duties by one or more employees of the Department of the Navy, and thus, the invention herein may be manufactured, used or licensed by or for the Government of the United States of America for governmental purposes without the payment of any royalties thereon or therefor.

BACKGROUND

The invention relates generally to gun-launched projectiles. In particular, this invention relates to submunition-dispensing rounds without incorporation of energetic materials.

As the United States Navy transitions from a "Blue Water" Combat Posture to a "Littoral" Combat Posture, naval warships become more susceptible to attack from non-conventional surface weapon platforms from shore-launched threats, such as coastal boats. The Mk 45-5" 54/62 Gun Mount serves as one of the primary surface warfare weapons aboard these vessels. Although there are multiple 5" (five-inch) diameter projectiles available for use against small boat threats, their fuzing safe and arm devices preclude their use at close ranges.

Additionally, rules of engagement often permit potential small boat threats to enter within the minimum fuzing safe and arm ranges, thus eliminating any potential self-defense contributions from the Mk 45-5" 54/62 caliber Gun Mount. Cruiser CG-47 (USS Ticonderoga) and destroyer DDG-51 (USS Arleigh Burke) class ships employ the Mk 45-5" 54/62 Gun Mount as a primary surface warfare weapon. The Mk 45 5" 54/62 Gun Mount is a fully automated, rifled, single-barrel weapon that stows and fires 5" 54/62-caliber ammunition. The weapon is capable of firing 70-lb projectiles at surface craft, low altitude aircraft, and shore targets.

SUMMARY

Conventional gun-launched projectiles yield disadvantages addressed by various exemplary embodiments of the present invention. Although there are multiple 5" (5-inch) diameter projectiles available for use against small boat threats, their fuzing safe and arm devices preclude their use at close ranges, eliminating any potential self-defense contributions from Mk 45-5" 54/62 Gun Mount. In particular, various exemplary embodiments provide an inert axisymmetric projectile for launching from a shipboard gun and dispersing submunitions at a target.

The projectile features include a base plug, a sabot housing, a submunitions package, a retainer ring, and a slip obturator. The sabot housing includes a plurality of sabot petals angularly arranged and attached to the plug. The housing includes a payload portion and a nose portion, with a passage corridor between these portions. The submunitions package is contained within the payload portion and constrained radially by the housing. The retainer ring constrains the petals for joining together. Upon launch the ring fractures from aerodynamic pressure and rotational forces. This causes the petals to unfurl, thereby releasing the submunitions package for dispersal.

The slip obturator engages the lands and grooves of the barrel rifling and seals the explosive gases behind the projectile, preventing them from advancing further up the projectile and potentially causing damage. The projectile "slips" at the interface between the slip obturator and the base plug, reducing the spin on the projectile that would have otherwise been induced by the barrel rifling. As the projectile progresses down the barrel, the structure of the sabot petals resist undesired deformations under the gun launch loadings of axial inertial setback and rotational inertia. The forward retaining band is restrained from deformation or failure by the radial restraint of the gun barrel itself.

Once the projectile exits the muzzle of the gun, the retaining band is no longer restrained by the barrel and fractures. The band suffers a controlled fracture by means of stress concentrations at geometric cross-section reductions along its circumference due to the combined loadings of axial inertial setback, rotational inertia, and aerodynamic stagnation pressure. Thus, absent restraint at their forward ends, the sabot petals begin to "peal" away from the projectile's central axis due to the centrifugal forces caused by rotation, as well as pressure resulting from petal contact with the ambient air. The petals then discard from the projectile and expose the interior submunitions package. The submunitions immediately begin to disperse radially due to their rotational inertia and their interaction with the ambient air. The dispersed payload is then disposed to engage the intended target. The remaining non-payload projectile components in flight are considered sacrificial materials.

BRIEF DESCRIPTION OF THE DRAWINGS

These and various other features and aspects of various exemplary embodiments will be readily understood with reference to the following detailed description taken in conjunction with the accompanying drawings, in which like or similar numbers are used throughout, and in which:

FIG. **1** is an isometric assembly view of an inert gun-launched projectile;

FIG. **2** is an isometric view of aerodynamic forces on the projectile;

FIG. **3** is an isometric view of the projectile unfolding;

FIG. **4** is an isometric view of the projectile unfurled;

FIG. **5** is an isometric view of the projectile with dispersal of submunitions;

FIG. **6** is an isometric assembly view of the projectile;

FIG. **7** is an isometric cross-section view of the projectile;

FIG. **8** is an isometric view of a retainer ring for nose installation;

FIG. **9** is an isometric view of an upper plate;

FIG. **10** is an isometric view of a lower plate;

FIGS. **11**A and **11**B are isometric views of a base plug;

FIG. **12** is an isometric view of a slip obturator;

FIG. **13** is an isometric view of a sabot petal;

FIGS. **14**A through **14**F are isometric views of the projectile in stages of assembly;

FIG. **15** is an elevation view of the projectile with envelope superimposed;

FIGS. **16**A and **16**B are isometric assembly and cross-section views of an alternate projectile configuration;

FIG. **17** is an isometric view of aerodynamic forces on the projectile;

FIGS. **18**A through **18**C are isometric assembly, isometric cross-section and isometric detail views of another alternate projectile configuration;

FIG. **19** is an isometric cross-section view of a modified alternate projectile configuration;

FIG. **20** is a schematic view of a warship with an effective envelope for the projectile; and

FIG. **21** is a schematic view of a test configuration used for evaluating performance of the projectile.

DETAILED DESCRIPTION

In the following detailed description of exemplary embodiments of the invention, reference is made to the accompanying drawings that form a part hereof, and in which is shown by way of illustration specific exemplary embodiments in which the invention may be practiced. These embodiments are described in sufficient detail to enable those skilled in the art to practice the invention. Other embodiments may be utilized, and logical, mechanical, and other changes may be made without departing from the spirit or scope of the present invention. The following detailed description is, therefore, not to be taken in a limiting sense, and the scope of the present invention is defined only by the appended claims.

Various exemplary embodiments provide an inert gun-launched projectile actuated by gun-launch induced pressures, or "pressure actuated projectile-inert" (PAPI) for standoff ship defense against proximate threats. The PAPI dispenses an internal payload of multiple fragments over an extended area without the use of a conventional fuze or energetic material. The PAPI uses the propelling gasses and acceleration-induced forces from gun launch to initiate internal mechanisms that release housing petals and dispense an internal payload towards a target.

PAPI is being developed to significantly increase the self-defense capabilities of warships against small, fast, asymmetric watercraft threats. Being inert renders the PAPI more convenient and safer to store, manufacture, and maintain. In this context, the term "inert" means without energetic material, such as an explosive or chemical propellant to disperse submunitions from the projectile upon reaching the target.

The PAPI increases capacity provided to the fleet for proximate ship self defense by providing a near-field projectile to be fired from a 5" (5-inch, e.g., Mk 45) diameter ship-board gun. As such the PAPI constitutes an axisymmetric munitions round. The PAPI is unique less due to its objective, but because of features related to achieving that objective. There are existing "shotgun" type rounds in use by the United States Army. However, these rounds disperse their payloads by means of projectile bodies that shatter apart at or near muzzle exit from the gun.

The PAPI dispenses its payload using mechanisms actuated by gun launch forces. These mechanisms employ controlled fracture of a retaining ring or the channeling of propellant gasses into the interior of the projectile during gun launch. Current research reveals no existing projectile that dispenses a multiple fragment payload by channeling propellant gas to actuate a mechanical device. The novelty of these embodiments can also be extended by the use of a slip obturator to retard spread of the submunitions by reducing spin when fired out of a rifled gun barrel. Exemplary embodiments use the slip obturator to reduce spin (i.e., angular rotation about the PAPI's longitudinal axis) to limit the distribution of the payload to a smaller area. Alternatively, the PAPI can use a regular obturator, thereby achieving full spin, and enabling the round to accurately traverse to the target.

Most shotgun type rounds are fired out of a smoothbore barrel. PAPI can be used on ships wielding large-caliber rifled barrels to engage close range, asymmetric surface threats. The inner spring and pressure actuation mechanism of PAPI can be used for other types and sizes of projectile or as a release mechanism initiated by inertial forces. The principle embodiments described herein include an aerodynamic design and a mechanical design. Each configuration is described in further detail.

FIG. **1** shows an isometric view **100** of a retainer ring PAPI, showing a nose portion **110**, a payload portion **120** and a base portion **130**. FIG. **2** shows an isometric view **200** of the retainer ring PAPI indicating the direction of aerodynamic forces **210** from forward motion after muzzle exit. These forces **210**, in conjunction with rotational inertial forces and axial inertial setback forces, induce circumferential tensile stresses at the joint tabs **220**, which induces fracture at an established load. This fracture enables separation of the petals on the nose portion **110** under the centrifugal forces **230** experienced.

FIG. **3** shows an isometric view **300** of the retainer ring PAPI after severing the joints **220**. Four angularly distributed sabot petals, distal **310**, starboard **320**, proximal **330** and port **340** are depicted in partial separation from a payload assembly **350** that mounts to a base plug **360**. Together these petals form a sabot housing and can be composed of an appropriate metal, such as an aluminum 7075 alloy, for example, and have thickness of 15 mils under the bore diameter as is consistent with most 5" projectiles. Artisans of ordinary skill will recognize that the design of four identical petals arranged in angular cruciform configuration is exemplary and other arrangements or numbers of petals can be contemplated without departing from the scope of the invention.

FIG. **4** shows an isometric view **400** of the retainer ring PAPI with the petals **310**, **320**, **330** and **340** having pealed away from the base plug **360**, thereby exposing the payload assembly **350**. An upper bulkhead or plate **410** and a lower bulkhead or plate **420** together axially constrain pellets or balls **430**, which are also radially constrained by the petals until sabot separation. The plates **410** and **420** are composed preferably of aluminum alloy.

Exemplary balls **430** can be composed of a dense metal, such as ⅜ (0.375 inch) diameter tungsten spheres. The base plug **360** features an angular groove **440** for receiving bottom edges of the petals. FIG. **5** shows an isometric view **500** of the retainer ring PAPI showing the balls **430** in dispersal and revealing a rod **510** connecting the upper and lower plates **410** and **420** and the base plug **360**. The rod **510** can be a ½-20 piece of all-thread shaft. The plates **410** and **420** can be secured by ½ (half-inch) hex nuts **520** (and accompanying flat washers) near the ends of the rod **510**.

FIG. **6** shows an isometric assembly view **600** of the retainer ring PAPI, similar to the view **100**, denoting a severable retainer ring **610**, the envelope petals, with starboard **320** and proximal **330** in the foreground, and the base plug **360** combined with an annular band or slip obturator **620**. The combination of the base plug **360** and the obturator **620** represents the base portion **130**. FIG. **7** shows an isometric cross-section view **700** of the retainer ring PAPI revealing the structural interior. A payload **710** can be disposed around the rod **510**, flanked by the upper and lower plates **410** and **420**. The payload **710** can comprise about 2800 balls **430** or other dispersing content for a weight of approximately 50 pounds-mass.

FIG. **8** shows an isometric view **800** of the retainer ring **610**, divided evenly into four angular segments and composed of 1020 steel. The ring **610** includes distal **810**, starboard **820**, proximate **830** and port **840** segments, separated by radially penetrating cuts **850** and held together with angular bridges **860** that correspond to the stress concentration tabs **220**. For a 5" diameter projectile, each bridge **860** can be ⅜ wide.

FIG. **9** shows an isometric view **900** of the upper plate **410**, which includes an outer disk **910** and an inner disk **920** and penetrated by a center through-hole **930** along the PAPI longitudinal axis. The outer and inner disks **910** and **920** form a radial groove **940** can contain an o-ring, which serves as an environmental seal for the submunition package area.

FIG. **10** shows an isometric view **1000** of the lower plate **420**, which includes an inner payload annular cap **1010** and an outer flange **1020** with a radial groove **1030** therebetween. The cap **1010** forms an annular cavity **1040**. The lower plate **420** includes a center through-hole **1050** along the axis. The rod **510** passes through the holes **930** and **1050**.

FIG. **11**A shows an upper isometric view **1100** of the base plug **360**. An inner flange **1110**, a mezzanine channel **1120** and an outer flange **1130** form the base plug **360**. The inner flange **1110** includes the angular groove **440** and a central hole **1140** to receive the rod **510**. FIG. **11**B shows a lower isometric view **1150**. The outer flange **1130** includes a pair of holes **1160** for receiving a spanner wrench during assembly.

FIG. **12** shows an isometric view **1200** of the slip obturator **620**, which features an outer annular portion **1210** and an inner annular portion **1220** that engages the mezzanine channel **1120**. The slip obturator **620** is preferably machined from nylon and serves as an engagement surface for the rifling, effectively sealing propellant gasses behind the gun barrel from the projectile and ensuring maximum transfer to the projectile.

FIG. **13** shows an isometric view **1300** of the distal petal **310**, identical to and interchangeable with the others. A nose segment **1310** (forming part of the nose portion **110**) connects to a payload envelope segment **1320** separated by an inner radial groove **1330** having a rectangular cross-section **1340** to restrain the inner disk **920** along its exterior rim. An annular tang **1350** protrudes longitudinally from the envelope segment **1310** to engage the angular groove **440** in the base plug **360**. Dowel pins **1360** within the thickness of the petal **310** provide frictional adherence to neighboring petals **320** and **340**. For the four-petal cruciform configuration, the eight or twelve dowel pins **1360** are preferably 3/16" diameter.

Assembly of the retainer ring PAPI can be described in the following illustrations. FIG. **14**A shows an inverted isometric view **1400** of a pair of petals, specifically distal **310** and port **340** combined together. The retainer ring **610** joins the nose segments **1310** of the petals. Each petal includes an annular arc **1410**. Joining the arcs **1410** by assembly of the petals into the sabot housing enables access to the rod **510** and nuts **520** (along with accompanying flat washers) for assembly. An annular ledge **1420** forms an upper boundary to the payload portion **130**.

FIG. **14**B shows an inverted isometric view **1430** of the petals **310** and **340** with the retainer ring **610** and further including the upper plate **410** with securing snap ring **1440** installed within the radial groove **1330**. An o-ring **1450** is disposed within the groove **940** of the plate **410**. FIG. **14**C shows an inverted isometric view **1450** including the payload **710** and the rod **510** installed in the PAPI assembly. Note that the payload assembly **350** comprises the payload **710** and the rod **510** flanked by the plates **410** and **420**.

FIG. **14**D shows an inverted isometric view **1460** including the lower plate **420** and the nut **520** on the rod **510**. The radial groove **1030** receives an o-ring **1470** as an environmental seal to protect the payload **710**. FIG. **14**E shows an inverted isometric view **1480** including the base plug **360** mounted on the tangs **1350** of the petals. FIG. **14**F shows an inverted isometric view **1490** showing the slip obturator **620** wrapped around the base plug **360**. The PAPI assembly can be constructed in such manner, with of course all the petals **310**, **320**, **330** and **340** joined together.

In order for the PAPI to be used effectively in the fleet, the interface with the Mk 45 Gun Mount's loading system should be considered. FIG. **15** shows an elevation view **1500** of the PAPI with the payload portion **120** and the ring **610**. An axisymmetric outline **1510** provides an envelope of the common contact points within the Mk 45-Mod4 projectile autoloader system. An ogive slope line **1520** provides reference to an in-service Mk 64 projectile body's interfaces with the projectile guides in the Mk 45-Mod4 autoloader system. A vertical line **1530** provides reference to the contact point of the upper projectile ram in the Mk 45-Mod4 autoloader system. A vertical line **1540** provides a reference to the contact point of a physical depression sensor in the Mk 45-Mod4 autoloader system. A vertical line **1550** provides reference to the contact point of the lower projectile frame in the Mk 45-Mod4 autoloader system.

FIGS. **16**A and **16**B show respective isometric assembly and cross-section views **1600** and **1610** of an alternative PAPI configuration. A retainer ring **1620** restrains a cruciform set of four sabot petals **1630** mounted to a base plug **1640** attached by a base plate **1650**. A slip obturator **1660** provides a radial surface for sealing hot gases from gun launch while traversing the muzzle. An upper plate **1670** and the base plate **1650** connected to a rod **1680** constrain a payload **1690**, such as the tungsten balls **530** in a submunitions payload package.

FIG. **17** shows isometric general and detail views **1700** of an alternative PAPI. Aerodynamic stagnation pressure **1710** (analogous to **210**) coupled with the gun-launch induced rotational inertia and axial inertial setback provide tensile stress to tabs **1720** (analogous to the tabs **220**) on the ring **1620**, causing the tabs to fracture. The forces of rotational inertia and axial setback **1730** (analogous to the forces **230**) then cause the petals **1630**, no longer restrained, to unfurl. The payload **1690** is then unrestrained and free to disperse on a target under its own rotational inertia, as well as aerodynamic reactions with the ambient air.

FIGS. **18**A, **18**B and **18**C show views of a mechanical pressure actuated PAPI: isometric assembly **1800**, isometric cross-section **1810** and isometric detail **1820**, respectively. The assembly view **1800** in FIG. **18**A features nose portion **1830**, payload portion **1835** and base portion **1840**. The cross-section view **1810** in FIG. **18**B features four petals **1845** in cruciform pattern enveloping a payload **1850** and a pushrod **1855** (that acts as a retaining pin). The petals **1845** are engaged by a petal collar **1860**, which is further enveloped by a base **1865** surrounded by a rotating band **1870**.

The detail view **1820** in FIG. **18**C shows the base **1865** containing a pressure plate **1875** suspended from the base **1865** by lower helical springs **1880**. An upper helical spring **1885** separates the plate **1875** from the petal collar **1860**. Orifices **1890** in the bottom of the base **1865** enable propellant gasses to enter the PAPI. The pressure from the gasses elevate the plate **1875** and thereby engage forked tabs **1895** on the pushrod **1855**.

Upon muzzle exit, the propelling gasses evacuate the pressure chamber at the rear of the projectile and the upper internal spring **1885** decompresses, drawing the pressure plate back to its original position, along with the latched pushrod **1855**. The downward motion of the pushrod withdraws it from a series of tabs within the forward portion of petals **1845**, enabling the petals to separate under the residual forces of gun launch. The petals would then be discarded, enabling the payload **1850** contained within to spread and disperse on target.

The delayed opening serves to produce a tight spread pattern for the internal payload **710**. Exemplary embodiments facilitate fine tuning into the system. By adjusting the size of the holes **1890** enabling pressure into and out of the system, or altering the size and spring stiffness of the springs **1880** and **1885**, the time required for the projectile to open can be customized to the optimal opening time.

FIG. **19** shows an isometric cross-section view **1900** of a modified embodiment of the mechanical pressure PAPI. Four cruciform petals **1910** envelope the nose **1915** and payload **1920**, each with a restraining tab **1930** contained within the nose **1915**. The petals **1910** are constrained by a petal collar **1940** screwed along a threaded interface **1945** into a base plug **1950**. A pushrod **1955** serves to engage the tabs **1930**. A rotating band **1960** and a mid-bore rider **1965** respectively surround the plug **1950** and the petals **1910**. A pressure plate **1970** is separated from the petal collar **1940** by an upper helical spring **1975**. The tabs **1930**, collar **1940**, pushrod **1955**, band **1960**, plate **1970** and the spring **1975** are analogous to the previously discussed **1895**, **1860**, **1855**, **1870**, **1875** and **1885** in both function and design.

The modified mechanical pressure PAPI functions in essentially the same manner as the mechanical pressure PAPI shown in FIG. **18A-18C**. However, the rear springs **1880** have been replaced with a rigid support, threaded interface **1945** has been added to improve component assembly, and a mid-bore rider **1965** has been added to increase the stability of the round as it travels down the barrel. The mid-bore rider renders the projectile more stable by reducing lateral sidesway, or balloting, as the projectile traverses the barrel.

FIG. **20** shows a diagram view **2000** of a naval destroyer **2010** equipped with a 5" Mk 45 gun **2020** capable of firing within an area **2030** along a downrange length **2040** and a spread width **2050**. A "Boston whaler" type target vessel **2060** represents a threat that can be neutralized with the restrainer ring or mechanical pressure PAPI. FIG. **21** shows a diagram view **2100** of a test configuration for the gun **2020** firing a PAPI along various downrange distances. Equipment and instruments, such as a mirror **2110**, video cameras **2120**, high-speed cameras **2130**, a tracking flight follower **2140** record data, and a witness plate **2150** marks distribution of the balls **430** and collects data.

In summary, the external structure for the general PAPI concept includes detachable envelopes, referred to as petals **310**, **320**, **330**, **340**, and a base plug **360**. The petals are restrained at the bottom of the projectile by the base plug **360**, which is surrounded by a gas-sealing obturator **620**, and restrained at the top of the projectile by a frangible retainer ring **610** or a mechanical retaining pin as the pushrod **1855**.

The PAPI embodiments can employ either the ring **610** or the pushrod **1855**. Both PAPI designs share the same mission and are completely inert and without conventional fuzes. However, the retaining ring PAPI actuates payload dispersion by creating fractures at areas of stress concentration in the retainer ring **610** due to the resulting forces of gun launch. The mechanical pressure PAPI actuates payload dispersion by enabling gun propelling gases into a rear chamber and using this pressure increase to elevate the plate **1875** and engage the pushrod **1855**, which is then disengaged from the sabot petal structure **1845**, enabling payload dispersion.

Returning to the view **2000**, upon launch from the gun **2020**, the projectile exits the muzzle and becomes subject to various aerodynamic forces. In general the projectile will experience about 110 psi of pressure due to aerodynamic forces at the nose of the projectile and about 288 psi of pressure due to the spin of the PAPI. The pressure on the nose portion **110** of the PAPI acts on the angled nose cone, and the angular velocity pulls the petals **310**, **320**, **330** and **340** of the projectile away from the center of rotation. These forces separate the petals being held together by the ring **610**.

Assembly of the PAPI includes the procedures described as follows. First as in view **1400**, the petals connect together by the dowel pins **1360** with silicone between each petal for environmental sealing purposes. This petal assembly slides into a groove in the retainer ring **610** and is secured in place with standard 4-40 screws. Hose clamps can be used at several locations along the payload portion **120** to keep the petals together until attaching the base plug **360**. The upper plate **410** acts as a forward constraint for the payload **710** and features the groove **1330** to fit an o-ring to environmentally and pneumatically seal the PAPI from the nose portion **120**.

Second as in view **1420**, the plate **410** with o-ring slides inside the petal assembly until reaching the groove **1330** on the petals. The snap ring **1440** can then be inserted into the groove **1330** in the petals to keep the plate **410** from falling out of the projectile. This snap ring **1440** also provides support for the petals to be torqued to the base plug **360**.

Third as in view **1450**, upon installing the upper plate **410**, the tungsten ball payload **710** can be installed. The precise number of balls is determined by the overall weight of the projectile, with the intent of keeping the PAPI to the standard 70±1 pounds-mass. For the volume considered, this configuration has room for just under 50 pounds-mass worth of payload which can equate to about 28000θ⅜" tungsten spheres or balls **430**.

The rod **510** is inserted before the payload **710** is poured into the payload portion **120**. This all-thread feature enables use of nuts **520** to torque and compress the payload **710** against the lower plate **420**, and enables threading into the base plug **360**. The lower plate **420** is somewhat more robust than the upper plate **410** to support the payload **710** during setback acceleration upon launch. The lower plate **420** also features an o-ring groove **1030** for environmental and pneumatic sealing.

Fourth as in view **1460**, the lower plate **420** slides into the payload portion **120** and contacts the payload **710**. The nut **520** (e.g., locknut and lockwasher) are threaded behind the lower plate **420** to enable torque to be applied. The entire assembly continues a process of vibrating and torquing down the nuts **520** until the payload **710** is sufficiently compacted. This compaction restrains the balls **430** from rattling around, but also acts to inhibit the payload **710** from pushing the petals radially outward by hydrostatic pressure setback forces upon firing. This hydrostatic pressure gradates from negligible at the upper plate **410** to a maximum at the lower plate **420**, causing premature separation of the petals. By compressing the load, these forces can be normalized and enabling the payload **710** to act as a unitary item instead of several individual balls **530**.

Under the pressures and temperatures experienced during shooting aluminum has been shown to melt and burn, causing small particles of aluminum to be deposited on rifle grooves of the gun barrel. The proceeding shot rips this aluminum from these grooves. With the aluminum comes the chrome plating intended to protect the inside of the barrel. Upon removal of the chrome plating, subsequent shots cause pitting in the rifling of the barrel. This pitting causes blow-by reducing the efficiency and accuracy of future rounds. To avoid such deposits, the base plug **360** is composed of steel.

Fifth as in view **1480**, the petals slide into the groove **440**, and the rod **510** threads into the hole **1140** of the base plug **360**. The two holes **1150** enable use of a spanner wrench to thread the base plug **360** onto the rod **510**. A bead of silicone will be applied to the groove in the base plate prior to assembly to provide an environmental seal. The base plug **360** turns into the rod **510** until the sides of the petals mate with the top surface of the inner flange **1110**.

Sixth as in view **1490**, the obturator **620** is prepared by heating in an oven to allow the nylon to expand, as is commonly accomplished with nylon bands. After heating, the obturator **620** is pressed onto the base plug **360** and permitted to cool and thereby shrink into position. This is a practice carried out on the M**1040** in addition to multiple other munitions with similar band designs. After installation of the obturator **620** onto the base plug **360**, the PAPI is completed and ready for load and launch in the gun **2020**.

While certain features of the embodiments of the invention have been illustrated as described herein, many modifications, substitutions, changes and equivalents will now occur to those skilled in the art. It is, therefore, to be understood that the appended claims are intended to cover all such modifications and changes as fall within the true spirit of the embodiments.

What is claimed is:

1. An inert axisymmetric projectile for launching from a shipboard gun and dispersing submunitions at a target, said projectile comprising:

a cylindrical base plug;

an annular sabot housing formed by a plurality of sabot petals arranged concentrically and separably attached to said plug, said housing including a payload portion and a nose portion, with a passage corridor between said payload and nose portions;

an upper plate pneumatically separating said nose portion said payload portion;

a lower plate pneumatically separating said payload portion from said plug;

a plurality of tungsten spheres contained within said payload portion and constrained radially by said housing; and

a separable retainer ring around said nose portion to constrain said plurality of petals, wherein upon launch from the gun, aerodynamic pressure fractures said ring and causes said petals to unfurl, thereby releasing said tungsten spheres for dispersal.

2. The projectile according to claim **1**, further comprising:

a slip obturator disposed around said base plug to reduce rotational spin of the projectile.

3. The projectile according to claim **1**, wherein said corridor is formed by an arc wall segment on each petal.

4. The projectile according to claim **1**, wherein said upper and lower plates comprise steel.

5. The projectile according to claim **1**, wherein said ring comprises steel, and said petals comprise aluminum alloy.

6. The projectile according to claim **1**, wherein said ring comprises a plurality angular segments corresponding to said petals, said segments joined by tabs that fracture in tension at an established load.

7. The projectile according to claim **1**, wherein said plug further includes an annular slip obturator for engaging a muzzle of the gun.

8. The projectile according to claim **7**, wherein said obturator comprises nylon.

9. The projectile according to claim **1**, wherein said spheres are ⅜" diameter and the projectile can be fired from a 5" diameter gun.

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